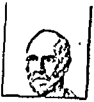
ALFRED B. NOBEL
1833–1896
Invented dynamite,
started Nobel Prizes

HIPPOCRATES
460–370? B.C.
"Father of Medicine"



MARIE CURIE
1867–1934
Discovered radium
and polonium

ENRICO FERMI
1901–1954
Produced first atomic pile and first
controlled nuclear chain reaction

THOMAS ALVA EDISON
1847–1931
Invented light bulb,
phonograph and mimeograph

NICOLAUS COPERNICUS
1473–1543
First astronomer to say that Earth
goes around the sun

LUTHER BURBANK
1849–1926
Invented new
varieties of plants

EDWARD JENNER
1749–1823
Discovered smallpox vaccine

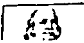
CHARLES DARWIN
1809–1882
Conceived the Theory of Evolution
through Natural Selection

WILLIAM HARVEY
1578–1657
Discovered the circulation
of the blood

GEORGE WASHINGTON CARVER
1864–1943
Experimented with
practical botany

SAMUEL F. B. MORSE
1791–1872
Invented telegraph and Morse code

LOUIS PASTEUR
1822–1895
Invented pasteurization



BENJAMIN FRANKLIN
1706–1790

YOUNG PEOPLE'S SCIENCE ENCYCLOPEDIA

Edited by the Staff of

NATIONAL COLLEGE OF EDUCATION, Evanston, Ill.

ASSOCIATE EDITORS

.EN J. CHALLAND, B.E., M.A., PH.D.
hairman, Science Department, National College of Education

DONALD A. BOYER, B.S., M.S., PH.D.
Science Education Consultant, Winnetka Public Schools, Winnetka, Ill., Science, National College of Education

W. RAY RUCKER, B.A., M.A., ED.D.
Former Dean of the College, National College of Education

EDITORIAL CONSULTANTS
ON THE STAFF OF NATIONAL COLLEGE OF EDUCATION

beth R. Brandt, B.A., M.Ed.
Beatrice B. Garber, A.B., M.S., Ph.D.
ne B. Cantelupe, B.A., M.F.A., Ph.D.
Robert R. Kidder, A.B., M.A., Ph.D.
H. Daugherty, B.S., M.A.
Jean C. Kraft, B.S., M.A., Ph.D.
K. Feinstein, B.S., M.A., Ph.D.
Elise P. Lerman, B.A., B.F.A., M.F.A.
Gallagher, A.B., M.A., Ph.D.
Mary-Louise Neumann, A.B., B.S. in L.S.
Lavon Rasco, B.A., M.A., Ph.D.

SPECIAL SUBJECT AREA CONSULTANTS

. A. Ehricke, B.A.E., H.L.D.
Norma R. Rucker, B.S.
:s B. Johnson, B.S., M.A., M.S.
H. Kenneth Scatliff, M.D.
ond J. Johnson, B.B.A., Senior tificate in Industrial Engineering
Ray C. Soliday, B.A., B.S., M.A. (Deceased)
Fred R. Wilkin, Jr., B.S., M.Ed.

THE STAFF

PROJECT DIRECTOR · WALLACE B. BLACK
COORDINATING EDITOR · JEAN F. BLASHFIELD
ART DIRECTOR · BEN ROSEN
PHOTO AND ART EDITOR · MARTHA O'ROURKE
PRODUCTION EDITOR · ORLANDO T. CURCIO

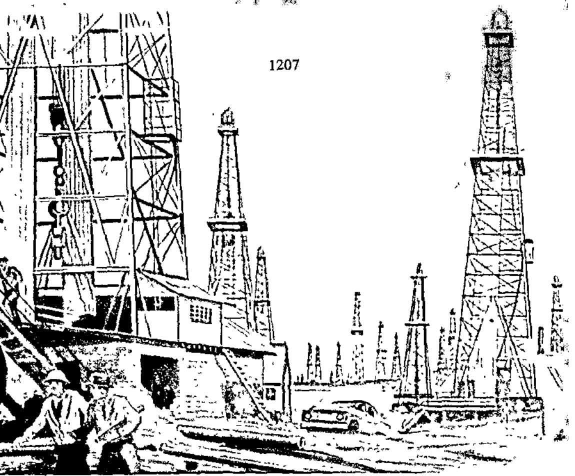
YOUNG PEOPLE'S SCIENCE ENCYCLOPEDIA

Edited by the Staff of

NATIONAL COLLEGE OF EDUCATION
Evanston, Illinois

VOLUME 13
OI - PI

McGraw-Hill Far Eastern Publishers (S) Ltd



A working oil field with wells and derricks

Oil well If one visited an oil field, he might see men smelling handfuls of mud from a pit. These oil workers, called *drillers*, are testing this mud for traces of oil. They can identify it by its smell.

Oil is one of the most valuable deposits in the earth's crust. Because of its many uses, it is poetically called "black gold." Chemically, it is a natural mixture of HYDROCARBONS because it contains a compound of hydrogen and carbon.

Oil is always found in such sedimentary rock layers as sandstone. Oil geologists look for layers that are shaped like a dome. The oil deposits found in the dome are called *anticlinal accumulations*. In most cases, oil is found near rock layers containing fossils. These are the remains of sea animals, such as clams or corals. Some oil is found in limestone or shale layers.

In addition to the dome deposits, the porous sandstone also acts as a reservoir to hold some of the liquids and gases. Oil men often speak of an *oil pool*. This does not, however, really mean a pool of oil. Oil is lighter than water and therefore is above water. When oil is trapped in a porous rock, some of the oil evaporates and exerts pressure on the surface. When a well is drilled down to the oil, the gas on top escapes or is tapped off. The rest of the gas may push out the oil with so much force that it causes a gusher. When this gusher occurs, the drillers cap the well, then put in pipes to storage tanks nearby.

The crude oil is allowed to flow into the tanks until the pressure of the gas lessens. Then the oil must be pumped. These wells are pumped until they cease to produce economically. Some wells can be pumped for years, while others are short-lived. Many wells can be drilled into the same pool to draw off the oil more rapidly. In big oil fields the derricks are almost as thick as trees in a forest.

rst successful oil well in the United
s drilled in Titusville, Pennsylvania,
. It required drilling to only 69
each this first well. Today drillers
much greater depths for oil. There
in Texas that reach down as far
) feet.
too valuable and drilling too costly
guess where it is located. Wells
d where the best scientific evidence
likely success. A dry hole or a
: drillers call a well that does not
is a costly mistake to investors.
logists use the magnetometer, seis-
and gravimeter in finding oil.
struments help them locate the
ck formations where oil may be
ne geologists also study the walls
s to look for outcroppings of par-
ck formations. Aerial photographs
tudied. Even changes in the num-
inds of plants in an area may offer
ne geologists take particular notice
or faulting of terrain. V. V. N.
: NATURAL RESOURCES, PETRO-

t An ointment is a semisolid
oily substance used simply for
ctive effect or to hold medi-
hich must be administered

s, SALVE
e Giraffe
H-kruh) *Gumbo* is the Span-
for okra. The fruit from this
nt is a long pod. It is used as
ble and in soups and stews.
e seeds are cooked and eaten
ould eat lima beans.

a plant and cut fruit section

Okra is an annual herb belonging to the MALLOW family. It is native to Africa and has been cultivated in the Old World for less than 2000 years. It is grown in the warm areas of the United States. Okra is propagated from seed.

Okra grows up to seven feet high. The large leaves have prominent veins. The flower is yellow with a red center. The fibers in the stem are extracted and used in making textiles and paper. H. J. C.

Oleander see Wild flowers

Olfactory see Nose

Oligocene see Cenozoic Era, Geologic time table

Olive The olive is an evergreen tree which grows up to forty feet tall. It has green fruit which turns to a purple color when ripe. It grows in a warm dry climate as in California, Florida and Arizona. It cannot survive below 15° Fahrenheit. Olives are native to the Mediterranean area.

Olive trees can live for over a century. The leaves are opposite, leathery and have a smooth margin. The white flower has parts in fours or divisible by fours. The fruit is classified botanically as a DRUPE. The exocarp and mesocarp is oily, fleshy and edible. The stony endocarp or pit contains one seed. Olive trees are propagated by stem cuttings, seeds or by *knaurs*, woody knots on the old trunk.

The olive has a *glucoside* which gives the raw fruit a very bitter taste. A solution of lye and sodium hydroxide removes it.

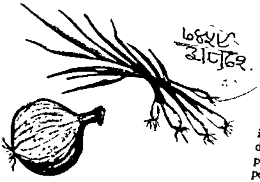
Olive is also the name of a plant family (*Oleaceae*) which includes syringa, privet, and forsythia. H. J. C.

Olive tree and branch

Olivine Olivine is a mineral that is also called *chrysolite* or *peridot*. It is the most common member of a group of silicates. It is colored various shades of green with rare brown tints. Olivine is a MAGNESIUM iron silicate.
SEE: MINERALS

Omnivore (OHM-nih-vohr) An omnivore is one of a group of animals that eats both animals and plants for its food.
SEE: BALANCE OF NATURE

Omnivorous see Animals, classification of; Balance of nature

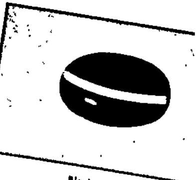


Red and green onions

Onion (UN-yuhn) An onion is a BIENNIEL herb related to the LILY. The bulbs are used as vegetables and for flavoring other foods. A chemical, *allyl sulfide*, escapes when the onion is cut and affects nerve endings in the nose. The nerve endings stimulate tears to flow from the eyes.

The onion grows to be two or three feet tall. The stem is flat, disk-like and underground. The fleshy underground leaves surrounding the stem are white. As they grow and receive sunlight, chlorophyll is produced. In the second year of growth, a flower stalk produces a flower cluster.

Onions are propagated by *seed sets* (small bulbs) and by bulblets that grow at the top of the stem instead of flowers. H. J. C.



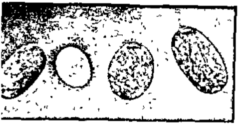
Black onyx J. Daniel Wil...

Onyx (AHN-icks) Onyx is a sem... precious stone. Greek myths spoke o... onyx as the fingernails of a goddess which were turned into stone as they touched water. The name *onyx* comes from the Latin word, *oniscus*, which means "lined" or "partly transparent," as a fingernail. The lines in this stone are parallel. They are white with brown, red, or green variations.

True onyx is a variety of AGATE, which is a form of quartz. It is formed from the dissolved mineral *silica*, which has been deposited in areas of ancient lava beds or petrified wood. The colors are caused by the deposition of other minerals. Mexican onyx is actually miscalled because it is a limestone variety, frequently found as cave or hot springs deposits. This is sometimes called *onyx marble*. It is more translucent than the true onyx.

Onyx is easily carved and takes a high polish. It is used as jewelry, ornamental stonework, mantles, and pillars.
SEE ALSO: GEM, QUARTZ J. A. D.

Opal (OH-puhl) The opal is one of the main precious stones. It has been mined for thousands of years for use as a jewel. Long ago, people thought the opal had magic powers. Some thought it brought bad luck, but the Romans wore opals as good luck charms. At the present time, Hungary and Australia produce the best opals, but the stone can also be found in many other parts of the world.



J. Daniel Willems
Black and white Australian opals

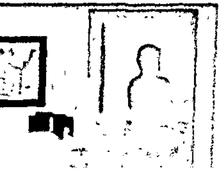
The common opal has a body color of
ky white, pale yellow, or black. The
ter opals are iridescent, which means
y show shifting lights of reds, yellows,
es, and greens. Opals are a variety of
RTZ. Their origins date back to prehis-
c times when water, seeping through vol-
ic ash, dissolved the mineral silica and
then deposited in petrifying wood or
cavities. The "opalescence" or irides-
ce of this gem, which is its source of
uty, is also its weakness. The lines of
ing colors are actually fractures or lines
train formed in its development. While
e lines reflect light, they can also cause
kage in the stone. An opal cannot be
into facets but must be polished into a
nded surface and carefully mounted.

J. A. D.

ALSO: GEM

que (oh-PAYK) Opaque means
TRANSPARENT to human eyes; able
top light rays and other forms of
iant energy such as infrared rays
bsorption and reflection.
LIGHT, TRANSLUCENT

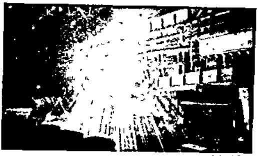
Window is translucent; wall is opaque



Open hearth process As the use of steel grew rapidly in Europe years ago, large quantities of rusty scrap iron were created. However, there was no readily available market for this type of metal. Sir William Siemens of England, therefore, felt compelled to invent a furnace which would re-melt the scrap and turn it into new steel. He accomplished this in 1856 with the discovery of the open hearth furnace. In 1864, Emile and Pierre Martin of France improved the process. Today it is alternately known as the *Siemens-Martin process.*

The open hearth process is the one generally used in the United States for making a good-quality steel. In 1942, over 90 per cent of the steel produced in this country was made by this method. The quality steel is used for the better class of rails; for structural steel such as girders for bridges, buildings, and tunnels; for shafts, armor-plate, and heavy guns; and wherever steel is to be subjected to much vibration. In addition to the very high-grade steel produced in this process, open hearth steel has three additional advantages. First, almost any kind of iron can be used as the charge. The *charge* consists of the impure materials which are refined in the process. Second, large quantities of steel can be made at one time. Third, the carbon content of the steel can be easily controlled.

In this process, the open hearth furnace, or converter, consists of a shallow, wide, saucer-shaped hearth and a low roof. It may be as long as fifty feet and as wide as twenty feet, with a basin about two feet deep. It is lined with either silica brick in the acid process, or with magnesia dolomite brick in the basic process (which is the process used in this country). The hearth holds the charge of scrap iron, solid pig iron, and molten pig iron direct from the blast furnace. Limestone is also added as a flux. A *flux* is a material purposely added to unite with the impurities. The waste product then formed is called the slag.



Inland Steel

"Tapping" the furnace, letting the molten steel run into the ladle

Inland Steel

Pouring molten steel from the open hearth ladle into ingot molds

through the molten mass, as in the Bessemer process, there is less iron oxide and dissolved gas in the finished product. By using as much as fifty per cent scrap iron or scrap steel, the oxidation of the impurities is speeded up considerably.

During the process, samples of molten steel are taken out at frequent intervals and allowed to cool and solidify. An analysis is made of the quality. Such treatment would be impossible in the Bessemer converter.

After eight or ten hours, the run is completed and the steel is tapped from the furnace. The slag is skimmed off from the top. Some *spiegeleisen*—a carbon-iron-manganese alloy—is then added to give the steel the desired composition of carbon and manganese.

Molten steel dissolves considerable quantities of carbon monoxide and other gases such as oxygen and nitrogen, which are liberated as the steel cools. This causes blowholes in the steel. To prevent this from happening, small portions of reducing agents such as metallic aluminum, silicon, or alloys of iron (ferro-titanium, ferro-vanadium) are added to the molten metal just before it is poured. The small, desired additions are called *scavengers*. The oxides they form are removed in the slag.

Fifty tons of steel or more are produced in the open hearth furnace every eight hours. In recent years, new steel processes using pure oxygen are being developed. They may replace some of the open hearth and Bessemer methods for making steel efficiently.

D. L. D.

SEE ALSO: BESSEMER PROCESS, STEEL

Operation see Surgery

Opiates see Narcotics, Opium

Opium (OH-pee-um) Opium has been used since ancient times. It is a narcotic drug made from the dried milk or juice from the pod of the unripe poppy *(Papaver somniferum)*. However, various useful drugs, such as codein, morphine, laudanum and paregoric, are obtained from opium. It has been said that opium has brought more relief to the world through its legal uses and more unhappiness through its illegal uses than anything else known to man.

Doctors use the useful opium drugs mainly for the relief of pain. Every American soldier in World War II carried morphine (from opium) in case he was wounded.

Improper use of opium derivatives (*opiates*) can lead to drug addiction—physical dependence on the drugs. Heroin, obtained from morphine, is the most widely used drug in illegal trade. Continued use of these drugs may lead to inability to follow a normal useful life and eventually leads to complete physical ruin and death. There is no known drug that will counteract the use of opium and its related NARCOTICS.

H. J. C.

Opium is obtained from the pod of an opium poppy

After the baby opossums are old enough to come out of the marsupial pouch, they ride on the mother's back

Opossum (oh-PAHS-um) The opossum is a *marsupial*, an animal with a pouch. Opossums are the only pouched animals in North America. This *common* or *Virginia opossum* is about the size of a cat and has grayish fur. It has a long, light-gray snout. With its long, hairless tail, the opossum can carry things or even hang upside down from a tree branch.

The opossum does not seem to be a very intelligent animal. Its only interests seem to be in keeping safe, comfortable, and free from hunger. It will eat anything—insects, fruits, other animals, eggs, or roots. The meat of the opossum is edible. When surprised by a hunter, an opossum falls into a state of shock and paralysis and appears to be dead. It is fear, not intelligence, that gives it this trick of "playing 'possum."

Opossums belong to a group of marsupials called *didelphids*, meaning that the female has two wombs. There is no placenta, however, which would be the source of food for the unborn offspring. As a result, newborn opossums are very small, undeveloped creatures. A litter often contains more infants than the mother can feed. First arrivals attach themselves to a nipple and the late ones starve. The survivors grow rapidly and crawl out of the pouch and attach themselves to the mother's back, where they ride until they can take care of themselves.

There are numerous other varieties of opossum in South and Central America. Like the North American opossum, they are generally neither friendly, beautiful, nor intelligent. The opossum has survived unchanged and untamed for thousands of years. C. L. K.

SEE ALSO: MAMMALIA, MARSUPIAL

Oppenheimer, J. Robert (1904-)
J. Robert Oppenheimer is the brilliant American physicist who is largely credited with building the first atomic bomb. He did not, of course, build the bomb by himself. He was the chief of scientists at the Los Alamos, New Mexico, laboratory where the work was done.

J. Robert Oppenheimer was born on April 22, 1904. His parents were gentle, cultured, and wealthy, having earned their fortune from importing textiles. Young Robert had every opportunity to succeed, and he made superb use of his good fortune. He was a brilliant boy, and was interested in everything except sports.

When he was five, the young Oppenheimer's grandfather gave him a small collection of rocks which led the boy to study geology. His mother taught him painting and music. When he was seven he began to write poetry, and his favorite toy was his microscope.

He returned to his interest in geology and began to correspond with professors of geology throughout America. By typing his letters so they would not betray his youthful age, he was nominated by one of the professors to the New York Mineralogical Club. Oppenheimer was eleven at the time. A year later he accepted an invitation to present a lecture to the members of the club on the minerals that form the bedrock of Manhattan Island. The members of the club were so astonished at his age that he had to allow them to recover their composure before delivering the lecture.

At nineteen, Oppenheimer enrolled at Harvard University, taking the required work and as many additional courses as possible. In three years he graduated with the highest scholastic record ever achieved at that university. He knew by then that

J. Robert Oppenheimer

he wanted to be a physicist, and he went to the famous Cavendish Laboratory in England to study with the great Ernest Rutherford and Niels Bohr. There he studied intently the structure of the atom. After leaving the laboratory he traveled to Göttingen, Germany, where he learned German and earned a Ph.D. degree by writing a paper in German on quantum mathematics.

Leaving Germany, he went to Zurich, Switzerland, and then on to Leyden, Netherlands, where after six weeks he was able to lecture in Dutch. He finally returned to the United States where he accepted positions simultaneously at the California Institute of Technology and the University of *California*.

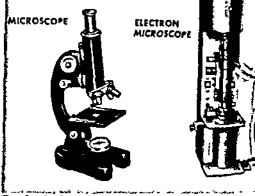
Meanwhile, ALBERT EINSTEIN was gravely concerned by the success of the German program of atomic research, and strongly urged President Franklin D. Roosevelt to establish a research laboratory to help safeguard the future of the free world. After two letters of warning from the eminent Einstein, the government established the Los Alamos laboratory.

As one of the leading theoretical physicists in the world, J. Robert Oppenheimer was the logical man to take charge of the project. In 1943, at the age of thirty-nine, he accepted the post and was placed over a staff of 4,500 workers. Two months after the first successful atomic bomb explosion, Oppenheimer resigned. He aided Congress in drafting the first laws to be concerned with the control and use of atomic energy, and he strongly urged the formation of an international organization to develop this energy.

In 1947 he was made director of the Institute for Advanced Study at Princeton, New Jersey, and continued to serve as a consultant to the Atomic Energy Commission. However, soon after the explosion of the first hydrogen bomb, he was suspended while being investigated by the government. In a dramatic summary, the board of examiners confirmed his loyalty, but advised that the nation's atomic secrets be withheld from him. At the present time all the facts surrounding the final decision are still not known. D. H. J.

Optic nerve see Eye, Nervous system

Optical illusions see Camouflage



Optical instruments Optical instruments are devices in which light is passed through lenses or prisms. Among the common optical instruments are the microscope, binoculars, *camera, spectroscope, periscope, and* telescope.

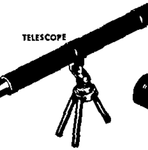
In the 1500's and 1600's, the first optical instruments were developed, following the discovery of the glass lens. The earliest telescopes and microscopes evolved because of the lens.

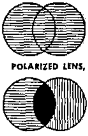
One of the original optical instruments to undergo numerous improvements was the spectroscope. *In 1666 Isaac Newton* sent a beam of light through a prism. The beam broke into a band of colored light, *similar to a rainbow.*

One kind of SPECTROSCOPE is basically a glass PRISM. All materials, when heated hot enough, radiate light. When this light from a particular substance is beamed through a prism, it divides into colored areas that are *distinct for the elements in that* substance. A trained spectroscopist can use this instrument to determine the chemical composition of laboratory "unknowns" and the elements in the stars and the sun.

Intensity of light is measured by one or another type of light meter. Photoelectric-cell meters convert light to electricity, and then the light strength is read on a dial. A laboratory PHOTOMETER compares a standard light source at a given distance with an unknown light at a measured distance; then by use of the *inverse square law*, the strength of the unknown light can be figured. *Measurement* units of intensity for light instruments are either in FOOT CANDLES or in the new units, *candelas*.

The speed of light can be measured by an optical instrument developed by Albert A. Michelson of the University of Chicago. He





determined that light in a vacuum travels at the speed of 186,284 miles per second.

Some instruments use *polarized light.* This is ordinary light that has been passed through a device that makes all its waves vibrate in one direction only instead of moving in several planes. This is done by directing the light either through crystals having a slit-like molecular arrangement, or else through plastic sheets coated with certain chemicals. Polarized light devices include camera filters, glare-reducing sunglasses, and car headlights. Biochemists use it in an instrument that measures strength of sugar solutions. Engineers who work with construction and manufacturing materials use polarized beams to reveal strains in glass and plastics.

From the time of Columbus to the present, optical instruments have become increasingly important to the scientist. He relies upon the microscope to see the micro, or small world, and upon the telescope to see the universe. Many discoveries in atomic physics, and in chemistry are due to the spectroscope. An even smaller world is now visible with the electron microscope.

Eye glasses, cameras, and binoculars are examples of the modern uses and improvements in optical instruments. P. F. D.

SEE ALSO: BINOCULAR; CAMERA; GLASS; LENS, MAN-MADE; LIGHT; MICROSCOPE; MICROSCOPE, ELECTRON; MIRROR; PERISCOPE; PRISM; TELESCOPE

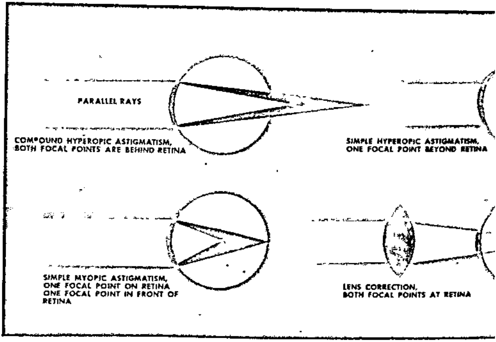
Optics Optics is that branch of science dealing with the generation, transmission and detection of electromagnetic waves with wave lengths greater than X-RAYS and shorter than microwaves. It includes the laws of LIGHT and its relation to vision, and also deals with the construction of lenses.

SEE: ELECTROMAGNETIC SPECTRUM; LENS, MAN-MADE

Optometry (ahp-TAHM-uh-tree) Optometry is a profession specializing in the protection and improvement of vision. The optometrist is one who practices the art and science of vision care. He is trained and licensed to make tests to determine the person's visual skills, especially in relation to his specific needs. When visual errors are found, he prescribes and provides any corrective lenses or visual training needed for adequate and comfortable sight.

The roots of the profession of optometry lie in the development of research in physics, mathematics, and optics, as well as in physiology and psychology. Modern optometry, however, really dates from the 19th century, when such men as Thomas Young, Herman von Helmholtz, Eduard Jaeger, and others, were busily engaged in Europe in measuring the eye and inventing instruments for testing sight. The results of their research are found in the applications used today. Development in the field of refraction led to the refractive testing of the eye, or optometry, as it is now known.

The word "optometry," in the sense of "diagnosis of refractive error" first appeared in 1870, and in the next thirty years optometry slowly evolved as a specialized vocation. Two outstanding leaders in the United States responsible for developing the profession were Charles F. Prentiss, who campaigned for legal recognition of the group, and Andrew J. Cross, who devoted himself to the establishment and improvement of the optometric educational facilities. By 1901, the first state law regulating the practice of optometry was passed in Minnesota. At the present time, the practice of optometry is recognized and regulated by state



laws in every state in the Union and by Federal law in the District of Columbia.

Optometry has encompassed new responsibilities in helping people's eyes to function properly under the increasing strain of modern living.

Contact lenses are optometry's contribution to many whose careers in athletics, aviation, on the stage, screen and television, depend on being able to see safely or to present the most aesthetic appearance.

Telescopic spectacles have been instrumental in returning the near blind to usefulness by helping them to see more than was previously thought possible.

The use of visual training and orthoptics (eye exercise) in the correction of squint (crossed eyes) and in the development or re-education of the visual skills for the improvement of visual performances was also due to the influence of optometry.

Vision is only one of the senses, but people rely on it more than on all the others put together. Most vision problems are due to *refractive errors* or inability of the eyes to focus light rays in the proper way. Glasses are the most common remedy for these errors. By relieving strain and permitting the eyes to function normally, glasses enable the individual not only to see clearly, but also to see efficiently and comfortably.

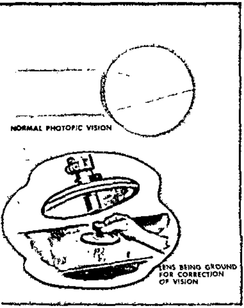
Faults of vision may be grouped into five classes: hyperopia (farsightedness), m (nearsightedness), astigmatism, presb (aging eyes), and strabismus (cross-ey

The condition describing a normal known as *emmetropia.* A properly fun ing eye refracts rays of light coming fr distant object (20 or more feet away that the image is brought to a focus a retina when that eye is at rest.

Hyperopia is a state or condition c eye which refracts parallel rays of lig a focus at a point behind the retina the eye is at rest. In this case, the r intercepts the converging rays of light fore they reach their focal point. Farsigh ness is corrected by placing a convex plus, lens before the eye. The power of lens is such that it will converge the before they reach the eye enabling them focus on the retina.

Myopia is a state or condition of an which refracts parallel rays of light t focus at a point in front of the retina w the eye is at rest. In such a case, the re intercepts the rays of light after they h converged to a focal point. Nearsightedn is corrected by placing a concave, or min lens before the eye. The power of the l is such that it will diverge the rays bef they reach the eye enabling them to focus the retina.

Astigmatism is the most common refr



tive error. It is a condition of an eye which refracts parallel rays of light so that they do not focus at one point. In most cases, astigmatism is the result of the cornea not being truly spherical. There are many forms of astigmatism. The correction of an astigmatic eye is obtained by placing a cylindrical or sphero-cylindrical lens before the eye.

Presbyopia means literally "old sight." It is a state or condition in which the near point of any eye gradually recedes. Presbyopia is the result of a gradual hardening of the lens in the eye, and is universally present in persons 40 years or older. The addition of a convex, or plus lens makes up for the loss in power and thus, allows clear vision at near distances.

Strabismus is a Greek word meaning "squint" and describes what is commonly recognized as cross-eye. This is usually caused by imbalance in the eyes. The two eyes do not function together and the ability to see three-dimensionally suffers. This condition is correctable by lenses, and/or visual training, and/or surgery. J. H. D.

Oral Oral means spoken and pertains to the mouth. In ZOOLOGY it refers to the same side of the animal as the mouth or mouth region.

SEE: ANIMAL

Orange see Citrus fruits

Courtesy Society For Visual Education Inc

A young orangutan

Orangutan (oh-RANG-oo-tann) *Orang* means "man" and *utan* means "jungle." Thus the orangutan is called "man-of-the-woods." It belongs to the APE family, and spends most of its life in tree tops, coming down to the ground only for water. An orangutan, if captured young, can be easily trained. Within weeks, it can be taught to eat, dress, and act well-behaved.

Some orangutans have reached the height of four and one-half feet. The males may weigh 200 pounds, the females are usually smaller. In spite of their great weight, they travel very rapidly; for though their legs are little and weak, their arms are strong and muscular, enabling them to swing rapidly from tree to tree rather than leap as many other PRIMATES do Their long, loose hair ranges from brick-red to brownish-orange, and their cheeks are wide and flat.

Orangutans are chiefly vegetarians, feasting on wild fruit, especially on the fruit of durain, shoots of screw pine, and fleshy leaves of various kinds. H. J. C.

Orbit The word *orbit* can be used to describe the path of any body revolving around another body. The path may be as simple as a circle, or as complicated as an ellipse.

Probably one of the oldest significant uses of the word orbit refers to the paths of celestial bodies as they revolve around the sun. Earth and other planets move in specific orbits as they travel around the sun, the force of the sun's grav pull. Planets with natural satellites the centers of the satellites' orbits.

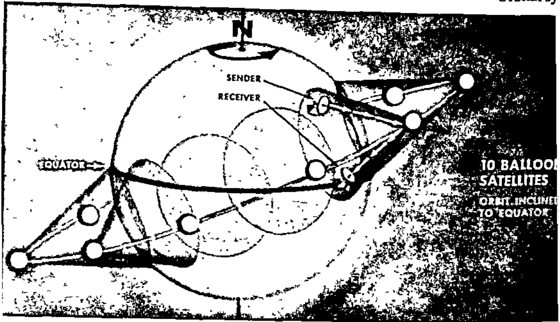


Figure 1—Example of a 10 satellite orbital system; circles indicate the approximate area in w ground stations can use the respective satellite for communications purposes

The revolving body always has some sort of massive center or nucleus around which it makes its orbit. For the planets, the sun is the center. Atoms also have particles which can be referred to as traveling in an orbit. These particles are the electrons which revolve about a nucleus composed of protons, neutrons, and other subatomic particles. At one time it was thought that these orbits were as simple as a circle. Now the paths of the electrons are recognized as three-dimensional orbits. If the path of the electron were to be traced, in time it would form a sort of "shell" around the nucleus. These paths are called *orbitals*.

The most recent application of the word describes the paths taken by the various man-made satellites as they revolve around the earth. Generally, these satellites have elliptical orbits with the ellipse oriented in various positions relative to the earth.

Regardless of how large or small the revolving body may be, there must always be a mass or nucleus around which the body can describe an orbit. The mass or nucleus plays a very important role in maintaining the balance of forces of the revolving body. If there were no nucleus, the body would no longer experience a force of attraction and it would float off into space A. E. L.

SEE ALSO APOGEE, ORBITAL SYSTEMS, PERIGEE, SPACE TRAVEL

Orbital systems Once a rocket spaceship escapes the pull of earth's gravity, it can be made travel in an orbit or path around t earth. *Orbital system* is a term us in astronautics to refer to a group such objects or satellites traveling the same orbit, or in a certain set orbits about the earth.

Typical examples of such systems are (1 a group of balloon satellites serving as pas sive repeater communication satellites, mor or less equally spaced in an orbit a fe hundred miles high so that at least one satel lite is always in the line of sight of a give ground station; (2) two groups of satellites each group spaced in a different orbit with the two orbits, for example, perpendicular to each other; and (3) a cluster of orbital installations made up of a space station and vehicles which ascend from the earth to meet the satellite cluster in orbit

Figure 1 above shows the earth, its north pole slightly tipped and a satellite orbit which is inclined with respect to the equator. Suppose that passive repeater satellites are to be placed into this orbit in such a manner that before a satellite leaves the field of view of a given ground station, the next satellite enters it. In this manner one can make sure

that the particular radio or television station always has at least one satellite available from which to bounce messages to other parts of the earth. The field of view of the satellite looking down on the earth is roughly circular, as is shown. The lower the orbital altitude, the smaller will be the diameter of this circle. In order to assure continuous coverages (that is, visibility of at least one satellite from a ground station at all times), the fields of view of the individual satellites must overlap. In other words, the coverage circles must be "linked" together. Each "link" involves two intersections for each of the two adjacent circles. Only the area between the intersections (cross-hatched) is covered all the time. The region above the northern intersection and below the southern intersection is covered only at times. It is easily seen that the lower the satellite orbit, the more satellites are required to provide continuous coverage, and the smaller will be the band which has coverage all the time. But as the number of satellites is increased, it becomes more difficult to keep them evenly spaced in the orbit. Slight differences in speed or direction of flight, as well as a twisting effect caused by the earth's equatorial bulge and, to a lesser extent, by the gravitational pull of sun and moon, will cause the satellites to drift slowly off course. As a result, the coverage circles will overlap more in one region, causing temporary "holes" in other regions. Keeping all these satellites in reasonable nearness to their intended places in the orbit is, therefore, like a very complicated juggling act.

Things become somewhat easier when the satellites are placed in orbits of greater altitude. The coverage circles are much larger so that fewer satellites are needed for continuous coverage of a particular zone of the earth. In addition, coverage can be increased greatly by spreading the orbital system over two or more orbits. Fig. 2 shows an example for two high-altitude orbits which are perpendicular to each other; in this case, one group of satellites travels in the plane of the equator, the other in a polar orbit. Because of the greater altitude than in Fig. 1, only four satellites are needed in the equatorial orbit and four in the polar orbit for continuous coverage of almost the entire globe. Thus, much greater coverage for communication or observation purposes can be achieved than with the larger number of satellites in the example in Fig. 1.

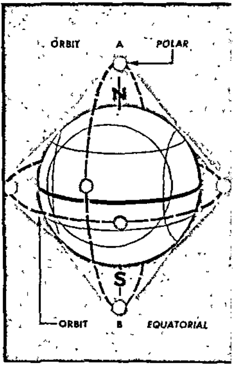


Figure 2—Example of an orbital system consisting of two orbits perpendicular to each other with four satellites in each orbit

Fig. 3 shows an orbital system which consists of a cluster of objects in a given orbit, and of vehicles which ascend from the earth's surface at more or less regular periods of time to join the cluster for a limited period before returning to the earth. Fig. 3 shows the example of a rather highly inclined orbit It is more difficult to get into such an orbit from a launch site at a given altitude than if both launch site and orbit were located in the plane of the equator. As shown in Fig. 3, the launch site crosses the plane of the satellite *twice* during one rotation of Earth. One of these crossings lies on the other side of the globe in Fig. 3. A launch is practical only when the launch site is near one of the two crossings.

Fig. 3 shows the ascent of a vehicle into the plane of the orbit. After the vehicle has completed this phase of its flight, it could theoretically continue to ascend directly into the satellite orbit. It is likely, however, that the satellite did not have the

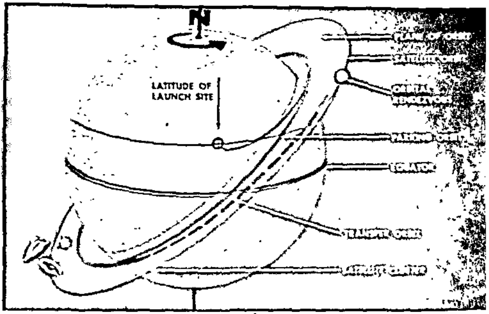


Figure 3—Example of an orbital system consisting of a satellite cluster and rendezvous ve[illegible] contact with the earth's surface

right position when the vehicle arrived in the orbit plane. The vehicle, therefore, would not meet the satellite when *arriving* in the orbit, just as bullets of the duck hunter's gun might cross the path of the duck's flight, but travel before or behind the ducks, missing them. It might, therefore, be necessary for the ascending vehicle to "wait" after arrival in the plane of the orbit until the right positions (constellation) of vehicle and satellite are formed. During the waiting period, the vehicle is "parked" in an orbit of lower altitude than the satellite orbit, but in the same plane. While in this parking orbit, the vehicle moves somewhat faster than the satellite. The right transfer constellation is, therefore, bound to occur sooner or later. For a vehicle in a parking orbit of, say, 100 miles altitude with the satellite in an orbit of an altitude of several hundred miles, the waiting period in the parking orbit will be no greater than 1.5 days; in many cases, it is only a few hours. Once the correct transfer constellation is attained, the vehicle's rocket engines are ignited again and propel the spacecraft into a transfer orbit which enables it to climb [illegible] and position of the satellite [illegible] as shown in Fig. 3. Once the [illegible] the transfer orbit, it will ar[illegible] minutes later at the critical [illegible] point. *Rendezvous* is French and

means "appointment" or "meeting" [illegible] counter is, therefore, frequently ref[illegible] as "*rendezvous maneuver*." It will [illegible] very important role in manned spac[illegible]

SEE ALSO SPACE TRAVEL, SPACE VI[illegible]

Orchard An orchard is a collec[illegible] fruit-bearing trees, especially A[illegible] PEAR, PEACH, PLUM, CHERRY, [illegible] COT and QUINCE. *Factors* su[illegible] wind, light, nourishment, col[illegible] heat influence the selection of [illegible] for an orchard.

A two-year-old lemon orchard planted [illegible] contour

U.S. Department of Agricul[illegible]

Helen J. Challand

Yellow orchids

F. A. Blashfield

Purple orchids, most popular for corsages

Orchid (OHR-kid) The orchid is one of the most interesting and beautiful of all flowers. It has many different shapes and colors. All of the 12,000 known species resemble one another, but some are shaped more like a butterfly, some like a dove, and some like a lady's slipper. These exciting blooms, which come from the tropics and subtropics, may be colored white, yellow, purple, green, or brown.

There are two classes of orchids: those that take their food from the ground (*terrestrial*) and those that take their food from the air (*epiphytal*). The terrestrial orchids are found in moist, marshy places and in greenhouses. They are known as hardy, native varieties and have their resting period in the winter months. The epiphytal orchids attach themselves to the bark of trees and depend upon the moist, humid atmosphere for water. Sometimes these orchids are incorrectly called *parasites*. They merely cling to the trunks and limbs of trees and take nothing from the tree itself. In this group of orchids are the most beautiful and most valuable species.

The orchid flower is irregular. Two of the three petals are alike. The third one takes on many shapes, forming a *lip*, or *labellum*. This structural arrangement facilitates insect pollination. One pistil and one or two stamens are joined together. The roots are fibrous, tuberous or bulbous.

Orchids are propagated by division of the rhizome, stem cuttings and by seeds. The latter are very small and require very sterile germinating materials. One variety of climbing orchid produces a long pod that is dark brown when ripe. VANILLA is extracted from this plant. J. K. K.

Order see Animals, classification of; Plants, classification of

Ordovician see Geologic time table, Paleozoic Era

Ore The ground that man walks on is made of soil and loosened rocks. Under this surface lies the earth's crust of solid rock, often containing valuable metals and other chemicals. Such matter is called *ore* and is taken from the earth (mined) and refined into materials useful to man. A number of refining processes are used to separate the valuable substances from the surrounding rocks.

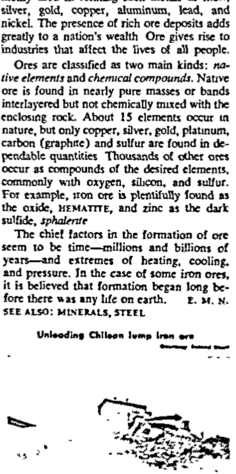
Roasting, smelting, and electrolysis are commonly used in refining such metals as IRON, silver, gold, copper, aluminum, lead, and nickel. The presence of rich ore deposits adds greatly to a nation's wealth Ore gives rise to industries that affect the lives of all people.

Ores are classified as two main kinds: *native elements* and *chemical compounds*. Native ore is found in nearly pure masses or bands interlayered but not chemically mixed with the enclosing rock. About 15 elements occur in nature, but only copper, silver, gold, platinum, carbon (graphite) and sulfur are found in dependable quantities Thousands of other ores occur as compounds of the desired elements, commonly with oxygen, silicon, and sulfur. For example, iron ore is plentifully found as the oxide, HEMATITE, and zinc as the dark sulfide, *sphalerite*

The chief factors in the formation of ore seem to be time—millions and billions of years—and extremes of heating, cooling, and pressure. In the case of some iron ores, it is believed that formation began long before there was any life on earth. E. M. N.

SEE ALSO: MINERALS, STEEL

Unloading Chilean lump iron ore



Oregano

Oregano (oh-RAY-gah-no) Oregano is an HERB that belongs to the mint family. Although some people call wild marjoram *origanum,* botanists say that origanum is a separate genus.

Oregano is a beautiful leafy perennial grown widely in the United States, Mexico, Italy, and Spain. It is used in powdered or dried-leaf form to season Mexican and Italian dishes, hot sauces, and bean dishes.

The herb plant may grow three feet high in warmer climates, has large clusters of pale, purplish-pink flowers, and oval, gray-green leaves. The flavor of oregano is much more pungent than the flavor of MARJORAM.

J. K. K.

SEE ALSO: MINT

Organ An organ is a many-celled part of an animal or plant made up of various tissues which work together to carry out some definite function. Examples are PLANT leaves and roots, and ANIMAL hearts and lungs.

SEE: ANATOMY, HISTOLOGY

Organic compounds Chemical compounds containing CARBON are defined as organic compounds. Most of the organic compounds also contain hydrogen, and a large number contain oxygen. Many contain nitrogen, sulfur, phosphorus, and other elements. The branch of chemistry now known as *organic chemistry* grew out of earlier studies of substances obtained from living organisms.

Natural organic compounds are found in plant and animal tissues. Familiar organic substances include sugar, fat, and petroleum.

Prehistoric peoples were familiar wit ganic compounds only in a practical wa the production of wine, they fermented g juice and produced alcohol. Soap was r from animal fats and olive oil. Dyes, as *indigo (a vegetable dye), alizarin* (i a plant root), and Tyrian purple (fro Mediterranean species of mollusk) used by the Romans and Greeks.

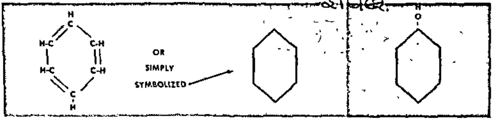
For many years people believed that ganic compounds were obtainable only f living organisms. Compounds derived f plant or animal sources were design organic material. In recent years, many the natural organic compounds have b made, or *synthesized,* by artificial proces *A familiar example is synthetic* rubl Moreover, thousands of carbon compour unknown to man in nature, have been s thesized.

While organic compounds are those c taining carbon, inorganic compounds those which do not contain carbon. Orga compounds outnumber inorganic co pounds. Carbon atoms form *covalent bor* with other atoms, linking them together chains and rings of many different sizes a compositions and producing the practica unlimited number of organic compounds.

Organic compounds, with very few e ceptions, are combustible. Inorganic sal *as a rule, do not burn. Organic* compoun usually exist as gases, liquids, or low-boilin point solids. Inorganic salts have very hig melting points. Although alcohol, sugar, ar similar compounds are *readily soluble* i water, water solubility for organic con pounds is the exception rather than the rul Many inorganic salts, on *the other hand* are soluble in water. The difference in solu bility may be attributed to the electroni structure and type of bonding of the com pounds.

Familiar organic compounds are the hydrocarbons. Hydrocarbons occur plentifully in nature, particularly in PETROLEUM. NATURAL GAS, the gas used for cooking and heating in homes, is composed mostly of methane, the simplest of the hydrocarbons. Other hydrocarbons are ethane, propane, butane, and pentane.

Another group of organic compounds are the alcohols. Alcohols are used as solvents and starting materials for synthetic processes. Rubbing alcohol is the common name for *isopropyl* alcohol. The ALCOHOL in



Benzene, C_6H_6, is the simplest of the benzene, or aromatic, group of organic compounds

A carbon benzene ring has a hexagonal formation

A benzene derived compound, phenol or carbolic acid

beverages is made by fermentation of sugars. An enzyme in yeast, *zymase*, converts the sugar to ethyl alcohol and carbon dioxide. Another alcohol, ethylene glycol, is widely used as an ANTIFREEZE in automobile radiators.

ETHER may be prepared by adding sulfuric acid to ethyl alcohol. It is used as a general anesthetic or as a solvent.

The *aromatic*, or benzene-ring, compounds are another important and large group. Benzene has the formula C_6H_6 and is not arranged atomically like the carbon compounds mentioned before. Its six carbon atoms are linked in a closed chain. Between alternate atoms there is a double bond of two pairs of electrons. Some benzene-ring compounds are fragrant substances found in plants; for example, balsams, resins, and perfume oils and flavorings. Still other benzene-ring molecules are made in animal and human cells; for example, hemoglobin in the blood and several hormones such as thyroxin and adrenalin all contain complex ring molecules.

Inorganic chemistry is used in geology, metallurgy, and mineralogy because it deals with inorganic materials such as gases in the atmosphere, water, rocks, minerals, metals and their salts, nonmetals and their compounds (i.e. sulfuric acid) Organic chemistry is applied in physiology, biochemistry, and in the science of producing synthetic materials. Through organic chemistry man has been able to improve upon nature by creating synthetic dyes, synthetic rubber, drugs and medicines, synthetic fibers, and many other useful compounds. Organic chemistry has given man a better understanding of the way in which living matter functions under normal conditions and of the causes of disease. J. R. S.

SEE ALSO: CHEMISTRY, HYDROCARBONS

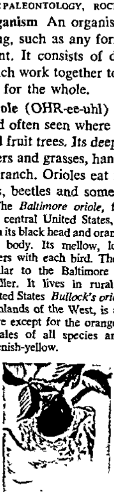
Organic rock Organic rock is rock formed from the remains of plants and animals. COAL, composed of plant material, and limestone, composed of shells and skeletons of sea creatures, are examples of organic rock.

SEE: PALEONTOLOGY, ROCKS

Organism An organism is any living thing, such as any form of animal or plant. It consists of dependent parts which work together to form common life for the whole.

Oriole (OHR-ee-uhl) The oriole is a bird often seen where there are shade and fruit trees. Its deep nest, woven of fibers and grasses, hangs at the end of a branch. Orioles eat mostly caterpillars, beetles and some fruits.

The *Baltimore oriole*, familiar in eastern and central United States, is a colorful bird with its black head and orange and black wings and body. Its mellow, low-pitched whistle differs with each bird. The *orchard oriole* is similar to the Baltimore but browner and smaller. It lives in rural areas in eastern United States *Bullock's oriole*, common in the farmlands of the West, is also like the Baltimore except for the orange on its head. The females of all species are dull yellow or greenish-yellow. E. R. B.



Baltimore orioles weave a hanging nest

Orion, the Hunter

Orion (oh-RYE-un) Orion is a large, bright CONSTELLATION which may be seen in winter. It is named after Orion, who was a great hunter. A row of three bright stars marks Orion's belt. Three fainter stars in a row represent a sword or a dagger hanging from his belt. Four more stars form a rectangle around the belt and sword. These mark his shoulders and knees.

Legends tell that Orion boasted he was the greatest hunter and no animal could kill him. A scorpion finally bit Orion and did kill him. The goddess Diana, a huntress, persuaded Jupiter to place Orion in the sky. Orion seems to be stalking the constellation, TAURUS, the bull. He is followed in his journey across the sky by Canis Major and Minor, his dogs. The scorpion is in the sky, too, but SCORPIUS is a summer constellation. This enemy of Orion is not visible when Orion is in the sky. Near the middle star in Orion's belt is a hazy cloud. This is the great Orion nebula, a gaseous cloud that reflects light from nearby stars.

BETELGEUSE, the bright red star on Orion's right shoulder, was supposed to be a ruby pin which held up his lion skin. Betelgeuse was the first star to have its diameter measured. Rigel, the bluish-white star diagonal to Betelgeuse, is pictured as the buckle on Orion's left shoe. C. L. K.

SEE ALSO: NEBULA, STAR

Orion, dogs of see Canis Major and Canis Minor

Ornithology see Bird

Ornithopter see Aviation

Eland, the largest antelope, is an ory

Oryx The oryx is one of the lar members of the ANTELOPE fam Both buck and doe have long sh horns. They inhabit open country Africa. The best known are the *bi* the *fringe-eared* and the *desert* o

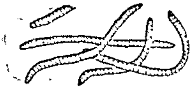
Courtesy Society For Visual Education

Osage orange tree and fruit

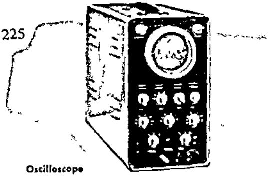
Osage orange (OH-sayj) An osa orange tree looks as though it loaded with green cannon balls. The green balls or fruit, from three to fi inches in diameter, are wrinkled an bumpy all over.

If the fruit or stem is cut, a bitter milk juice will flow. The branches have shar thorns and are sometimes planted clos together for a hedge. The ROOTS are colore a brilliant orange. The Indians and earl settlers at one time used these roots as dye for their clothing and blankets. V. V. N

Oscillator An oscillator is an electric circuit which produces alternatin voltage of required frequency. In RADIO transmitters, the *electromagnetic* waves produced by an oscillator serve as CARRIER WAVES. Audio oscillators vary frequency in test equipment and MUSICAL INSTRUMENTS.



Oscillatoria



Oscilloscope

Oscillatoria (ah-sill-uh-TOH-ree-uh) Oscillatoria is the growth sometimes found on the outside of flower pots. It is a plant without roots, stems, leaves, or flowers. It is a blue-green alga, the most simple form of plant. It reproduces by simple cell division.

Oscillatoria produces long, slender cells without organized nuclei. A blue pigment and CHLOROPHYLL are often present, though not localized in PLASTIDS This alga is found on moist banks and cliffs or in the water. It has a jellylike sheath, more visible in single-celled or colonial forms than in thread-like (filamentous) forms.

A species of oscillatoria is red and gives the Red Sea its name. P. G. B.

SEE ALSO: ALGAE; REPRODUCTION, ASEXUAL

Oscilloscope An oscilloscope is an electronic instrument which displays the image of an electrical signal on a fluorescent screen. The "heart" of the oscilloscope is a cathode-ray tube. Oscilloscopes are used to look at the waveform (shape) of an electric signal and to measure the strength and duration of very high frequency currents and voltages. When a serviceman fixes a television set, he looks at the waveform of the signal on the oscilloscope screen and compares it with a picture of what he should see.

An oscilloscope with *long persistence* has a screen coated with a special type of phosphor (the material which glows when bombarded with electrons) which will continue to glow at the spot the electrons have hit for a few minutes after the electrons have been removed.

It is sometimes necessary to compare two traces. This is most easily done using either a dual-trace oscilloscope or a dual-beam oscilloscope. The *dual-trace* oscilloscope has a single electron beam which traces out one signal and then switches to trace out another signal. The long-persistence screen of this type of oscilloscope displays both traces at the same time.

Dual-beam oscilloscopes, on the other hand, use two electron beams. Each beam traces out a different signal Both signals are displayed simultaneously on the screen. A long-persistence screen is not necessary in a dual-beam oscilloscope. M. R. L.

SEE ALSO: CATHODE RAY, CATHODE-RAY TUBE, ELECTRICITY, ELECTRONICS

Osier see Willow

Osler, Sir William (1849-1919) Sir William Osler was a Canadian physician who became famous because of the improvements he made in the teaching and practice of medicine. As the first chief-physician of Johns Hopkins Hospital in Maryland, he introduced the practice of having young doctors serve long terms as resident doctors in the hospital. When Johns Hopkins School of Medicine opened, he sent students into the wards to study at the bedsides of patients.

Because of his concern for training good physicians, Osler is primarily remembered as a great teacher. He also made specific studies of the blood and heart, malaria, cholera, and tuberculosis. He was often called "the great physician."

Born to pioneer missionary parents serving the Church of England in Tecumseh, Ontario, Canada, William lived eight years in the rugged poverty of the north woods. The family then moved to Dundas where William and his brothers and sisters could secure an education. Because of his boyish

pranks, William was withdrawn from the local elementary school and sent to a boarding school in Barrie. Although he continued to be mischievous, he proved himself again and again to be an excellent scholar.

When he was sixteen, young Osler went to Weston, a preparatory school similar to Eton in England. It was there that he met the two men who were to determine the course of his life: Reverend William A. Johnson, founder and warden of the school, and Dr. James Bovell, an outstanding physician and teacher of medicine in Toronto. After receiving his medical degree from McGill University in Montreal, he traveled and worked in Europe and Canada. In 1888 he assumed the position of professor of the principles and practice of medicine at Johns Hopkins University. He also was named Physician-in-Chief at the new Johns Hopkins Hospital affiliated with the University. In 1911 he was knighted and made a baronet.

One book written by Osler, *The Principles and Practice of Medicine*, has been used for many years as a medical textbook. He spent the last two years of his life cataloging his priceless medical library which he bequeathed to McGill University. D. H. J.

Osmium (AHZ-mee-um) An Englishman named Smithson Tennant discovered osmium, element number 76, in 1804. He named it *osmium* after a Greek word meaning "smell" because its compound with oxygen had a sharp and irritating odor. It is a hard grayish-white or bluish-white metal.

Osmium and a similar metal, IRIDIUM, form an alloy which is very hard. This alloy, *osmiridium*, is sometimes used for fountain pen points and phonograph needles.

Osmium is a dense element, a member of the PLATINUM group. It is more than ten per cent heavier than gold.

The oxide of osmium, osmium tetroxide or peroxide, OsO_4, is important in synthetic chemistry. The atomic weight of osmium is 190.2. J. R. S.

SEE ALSO: ELEMENTS

Osmosis (ahss-MOH-siss) Molecules, the tiny pieces which make up all matter, tend to move from where they are more concentrated to where they are less concentrated. This equalizi[ng] movement, called *diffusion*, occurs b[e]cause the random motions of the mo[le]cules make them move around. [If] *there are more molecules of one ki[nd]* in a certain region than outside th[at] region, more molecules will move o[ut] of that region than move into i[t]. Osmosis is the DIFFUSION of wat[er] through a membrane that will n[ot] allow other, larger molecules to pa[ss] through it. Such a membrane is calle[d] *semipermeable*.

Many chemists and physicists include [in] osmosis the passage of any gas, liquid, [or] dissolved solid through a semipermeabl[e] membrane. Other scientists restrict the ter[m] to the passage of liquids and dissolved sub[-]stances, such as food and minerals, throug[h a] membrane. Most biologists, however, stat[e] that osmosis is the movement of wate[r] through a semipermeable membrane fron[m] where water is more concentrated to wher[e] it is less concentrated.

The classic experiment which show[s] osmosis uses parchment as the semiperme[-]able membrane. The parchment allows wa[-]ter, but not molasses, to pass through.

The force by which water moves into the solutions is called *osmotic pressure*. Osmotic pressure depends upon the concen-

The classic experiment in osmosis uses a parchment membrane, thistle tube, molasses and water. The liquid rising in the tube is a solution of both fluids because diffusion occurs only one way—the water moves into the molasses

✳ THINGS TO DO

WHICH MATERIALS WILL GO THROUGH A MEMBRANE?

When two solutions are separated by a thin membrane, the stronger or more concentrated solution will pass through if the membrane is permeable to it. Set up several osmometers to determine which solutions go in which directions.

1 Carefully remove part of the shell at the large end of an egg. Do not break the membrane under the shell. Immerse the egg in a glass of water. What happens?

2 Hollow out the top end of a carrot or beet. Insert a one-holed cork into the hole and put melted wax around it to seal it closely to the root. Put a glass tube in the cork. Now place the carrot in colored water. What comes up the tube? Clear water or colored water?

3 Remove the bottom of a test tube by winding a wire around it and then holding this end over a flame. When the wire becomes hot it will break the end off the tube. Cover this open end with a cleaned piece of sausage casing. Fasten the membrane on tightly with a rubber band. Fill the tube with a molasses solution. Cap the tube with a cork and glass tube. Suspend the tube in a beaker of water from a ring stand. After several hours, observe the direction of liquid movement.

tration of water inside and outside the membrane and upon temperature. The greater the difference in concentrations and the higher the temperature, the greater the osmotic pressure. This pressure is frequently measured in pounds per square inch. Osmotic pressure is one of the important forces which makes sap in plants rise.

Living cells have a membrane surrounding them through which osmosis can take place, but this membrane can allow or not allow molecules to pass into and out of the cell much more selectively than a simple semipermeable membrane can. J. K. L.

Osprey (AHS-pree) The osprey is a large bird, commonly known as the *fish hawk, bald buzzard,* or *fishing eagle.* The osprey is found throughout North America but prefers the South in the winter. The osprey dives feet first into the water and grips fish in its powerful talons. It is most often found along the coasts and near large lakes and rivers, but sometimes makes its home inland. It resembles the bald eagle but is smaller in size and has white underparts.

The osprey is about two feet long, with a wing-spread of four feet from tip to tip. It is a rich brown color, and its tail is banded with brown and white. The upper parts of the head and neck are whitish, and the legs have a bluish cast. The voice of the osprey is seldom heard but sounds like the peeping of baby chicks. Its nest looks like a bushel basket of sticks, built high in a dead tree, on a deserted building, or on the rocky ledge of a cliff. M. R. L.

SEE ALSO: BIRDS OF PREY

The osprey is a fish-eating hawk

Ossification (ahs-ih-fih-KAY-shun) Ossification is the formation of BONE; the changing of CONNECTIVE TISSUE or of CARTILAGE into bone through progressive changes in the cells making up the tissue. As large mammals, such as man, grow, the skull becomes ossified.

SEE: SKELETON

Ostrich (AWS-trich) The ostrich is one of the few birds in the world which cannot fly. It has long legs which help it to run over the African grasslands, where it lives. It can run as fast as four-legged grazing animals, up to 35 or 40 miles an hour. Its diet is mostly vegetarian, including seeds and plants, but it also eats small mammals, reptiles and insects. Almost everything about it is big except its head. A male may stand five feet high at the back, and weigh over 300 pounds. The female is smaller.

The male's body is black and the feathers in the tips of its wings and tail are white. They can be pulled without hurting the bird. This is done annually to ostriches on farms in Africa and Europe and the feathers or plumes are sold for decoration. The head, legs and thighs are naked of feathers. It is the only bird with two toes.

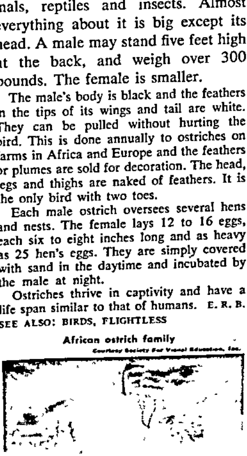
Each male ostrich oversees several hens and nests. The female lays 12 to 16 eggs, each six to eight inches long and as heavy as 25 hen's eggs. They are simply covered with sand in the daytime and incubated by the male at night.

Ostriches thrive in captivity and have a life span similar to that of humans. E. R. B.

SEE ALSO: BIRDS, FLIGHTLESS

African ostrich family

Courtesy Society For Visual Education, Inc.



Chicago Natural History Museum

Sea otters of the Aleutian Islands

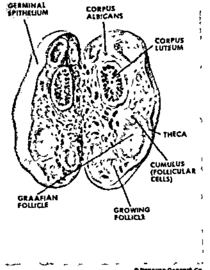
Otter (AHT-er) Otters are long, sleek, fur-bearing animals with long tails, short legs, and broad, webbed feet. They spend most of their time in water and are excellent swimmers, divers, and fishermen. These flesh-eating (*carnivorous*) mammals are closely related to WEASELS. There are two groups of otters, river otters and sea otters.

River otters grow to be about four feet long. Their grass-lined burrows may be found along the banks of streams and rivers. These very playful animals love to slide down muddy or icy hills. They dive and swim in the water, catching slippery fish with their sharp strong teeth. Otters also catch crayfish, snails, shellfish, frogs, and insects. River otters are active all year. Their bodies are covered with two layers of thick, water-repellent fur. The pale gray undercoat is short and soft, while the dark brown outercoat is long and stiff.

The otter's body is insulated by a layer of fat under the skin. In the early spring, two to three babies are born to each mother otter. They are cared for several months by the mother.

Sea otters are larger and have shorter tails than river otters. They live in the vast beds of seaweed or KELP in the North Pacific. Their range is from the coast of North America north of Oregon to the Asian coast north of the Kurile Islands.

Only one baby sea otter is born at a time. The mother sea otter often sleeps on her back and carries her dependent baby on her chest. Sea otters seem to enjoy floating on their backs. They dive to great depths to catch crabs, mussels, snails, sea urchins, starfish and other marine life. They bring the food up to the surface, roll over to their backs, crack open their dinner and use their chests as tables to eat on. D. J. A.



Cut section of an ovary in a woman

'ary (OH-vuh-ree) The ovary is the (gland in a female. Within the ary, germ or sex cells develop or ıture into egg cells (*ova*) ready for :tilization.

There are two ovaries, each about .e and one-half inches long and ree-fourths of an inch wide in each male. When a baby girl is born, she .s about 350,000 immature ova in e ovary, but only about 400 ever ature.

The maturing of ova is controlled ' hormones secreted by the ovary ıd by another gland, the PITUITARY, cated below the brain.

Germinal epithelium surrounds the ovary. :neath it is the *cortex*, composed of fibrous d reticular connective tissue. It contains :veloping ova surrounded by follicle cells. denser part of the cortex immediately ıder the epithelium is called the *tunica buginea*.

The central part of the ovary is called the *edulla*. Developing ova are absent but ere are smooth muscles, elastic fibers, and e branches of ovarian arteries and veins.

As a germ cell matures, it enlarges. The ›llicle cells divide by mitosis until a large ›llicle filled with liquid is formed.

This is known as the *Graafian follicle*, and the mature egg is attached to one side. The follicle ruptures or breaks, and the egg passes through the oviduct to the uterus.

The cells in the ruptured follicle, now known as the *corpus luteum*, secrete a yellowish hormone (*progesterone*) which fills the cavity. If the egg is not fertilized the follicle degenerates. J. C. K

SEE ALSO. HISTOLOGY, MENSTRUATION, MITOSIS AND MEIOSIS, OVUM, REPRODUCTIVE SYSTEMS

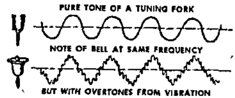
Oven bird see Warbler

Overtones Musical sounds have three characteristics: pitch, loudness, and quality of tone. The tone quality, often called *timbre*, is determined by the number, strength, and pitch of all the separate tones comprising the one principal tone. This principal tone is called the *fundamental*—that is, a tone of a single frequency or pitch. The other weaker tones, not heard as separate tones, are called *overtones* (or *harmonics*, if they are multiples of the fundamental). A tone with a frequency twice the fundamental is called the first harmonic.

No musical instrument ever produces a pure tone, that is a tone of a single frequency. It actually produces a mixture of tones. A tuning fork, mounted on a resonating box, will usually produce a pure tone, with only the fundamental present. A pure tone is dull and colorless. The richness of the tones of musical instruments and of the human VOICE is due to overtones. The more overtones, the richer the tone quality.

If the same note, say middle C, is played on the violin, clarinet and piano, the pitch or fundamental frequency is the same. However, the quality of the tone differs in each case, and the listener with a little practice can distinguish the instruments producing the given notes. The difference in quality between instruments is due to the number and strength of the overtones produced at each frequency.

When a musical sound is made, the lowest and usually the strongest frequency in the mixture is the fundamental. It is the fundamental tone that seems to be heard.



The higher-pitched sounds are the overtones. These are generally weaker vibrations of higher frequencies which affect the tones heard.

A string on a certain instrument may give, in addition to the fundamental of 200 vibrations per second, an intense overtone of 400 vibrations per second, with a moderate intensity; another of 1200 vibrations per second with less; and very faintly, others of 1600 and 2000 vibrations per second. A string on a different instrument may give the same fundamental, and the notes of 400 and 800 vibrations rather faintly, but may make the higher pitched overtones relatively loud. These two instruments thus differ in tone quality. Whenever the qualities of two tones of the same pitch are different, the overtones in the two are different either in pitch or loudness, or in both. D. L. D.

SEE ALSO: MUSICAL INSTRUMENTS, SOUND

Oviparous (oh-VIPP-uh-ruhs) Oviparous refers to an animal which reproduces by means of eggs in which the young develop inside the eggs and the eggs hatch after they have left the mother's body. Birds are oviparous.

SEE: EGG, REPRODUCTIVE SYSTEMS

Ovulation see Ovary, Ovum

Ovum (OH-vuhm) An ovum is the reproductive cell produced by the ovary. The production and release of this ovum or egg by the ovary is called *ovulation*. FERTILIZATION takes place when the ovum comes in contact with the male cell called the SPERM, and the two unite, forming a *zygote*. This divides by MITOSIS, grows and differentiates into a new individual *embryo*.

Many plants and animals come from fertilized ova or eggs.

SEE: EGGS; EMBRYOLOGY; GAMETE; OVARY; POLLINATION; REPRODUCTION, SEXUAL

Owl Owls are found all over the world. Most of them do their hunting at night and all are flesh eaters, preying mostly on small rodents, such as mice. They have large heads, hooked beaks and talons and large eyes set in flat feathered disks. Their calls vary, depending on the species, from screeches and hoots to whistles and low moans.

Night-flying owls often prey over the same territory hawks cover during the day. They are well adapted for night hunting. Their eyes are ten to 100 times as sensitive to low light as man's and their ears, large slits in the sides of the head, enable them to hear the slightest rustling. Their flight feathers are fringed for silent attacks. They plunge at their prey and strike with their hooked talons. They differ from other birds of prey in that they may swallow prey whole and digest the meat, casting up indigestible items in the form of pellets.

There are about 133 species of owls, ranging from as small as a sparrow to large as a rooster. A few owls, such as the pygmy and hawk owl, hunt by day. They are solitary birds, some living far from civilization and others preferring human habitations where rodents are plentiful.

The smaller owls nest in holes in trees or on the ground and the large owls build nests. The female lays white, round eggs, from one to 12 depending on the species. They hatch at intervals so the young vary in size. E. R. B.

SEE ALSO: BIRDS OF PREY

Ox see Oxen

Some of the most common owls are the barn owl (left), horned owl (center), and screech owl (right)

Arctic musk ox

Oxen Oxen is a general term covering a group of hoofed animals belonging to the *bovine* family. They have some of the same body structures as cattle, sheep and goats. The only two wild oxen in North America are the bison and musk ox. The *kouprey* of Cambodia and the *gaur* (or *seladang*) of India are oxen of other countries.

Oxen generally have stocky bodies, cloven hoofs, large lateral horns and a long tail Their stomachs have four chambers and are well adapted for digesting harsh grasses

The *bison* is erroneously called BUFFALO in the United States. This wild ox is almost extinct in the wild state. Bison breed well in captivity. Their shaggy fur is brown to brownish black. The male may weigh up to 1700 pounds while the female is somewhat smaller. Both sexes have horns that are never shed. The hump-like shoulders, common in oxen, are quite pronounced.

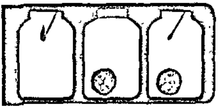
The *musk ox* is smaller than the bison and the domestic ox of other countries. It weighs under 500 pounds. It gets its name from the strong musk odor it gives off when excited. Its shaggy hair is very long. As with bison, both the male and female musk oxen grow horns which are never shed, only new horny tissue is added annually. They are found roaming in groups around the Arctic region.

The *seladang* or *gaur* is a fast runner who spends its wild life in the forests of the Malayan Peninsula and India. It has horns measuring two and one-half feet long and stands about six feet high. The *Brahman ox (zebu)* has been brought to areas in southern United States from Africa. They are adapted to living and working in warm climates. H. J. C.

SEE ALSO: RUMINANT, UNGULATA, YAK

✳ THINGS TO DO

WHAT ELEMENT IS NECESSARY FOR THE PROCESS OF OXIDATION?



1. **Light a match and insert it into an empty glass jar. The match continues to burn because oxygen is present.**
2. **Now put a ball of steel wool into the jar. Sprinkle it well with water. Cover the jar and permit it to stand for several days.**
3. **Observe the change occurring to the steel strands. The steel wool is chemically combining with something in the jar to cause it to rust.**
4. **Remove the cover of the jar and immediately insert a lighted match. What happens to the flame? Steel wool cannot oxidize nor can fire burn without oxygen or a similar substance such as chlorine.**

Oxidation (ox-i-DA-tion) Oxidation is the process is which a substance combines with oxygen or with another substance such as chlorine. Oxidation may be rapid, as can be seen in a material burning in air, or slow, as in the rusting of iron. Regardless of the speed of oxidation, the process involves a substance uniting with oxygen to form an *oxide*.

Most metals combine readily with oxygen to form oxides. Some of the products, in order of quantity, are silicon dioxide, SiO_2; iron oxide, Fe_2O_3; aluminum oxide, Al_2O_3.

It was once believed that in the combustion process substance lost weight. The substance given off was called *phlogiston*. The theory involved substances that were "snuffed out" when burned in enclosed spaces. It stated that the saturation of the air by phlogiston made the burning object unable to release any more phlogiston to the

air. Many prominent scientists, including Joseph Priestley, who was one of the first chemists to produce oxygen, believed in the phlogiston theory. For example, Priestley called the oxygen he produced "dephlogisticated air" because he believed that he had removed the phlogiston from the air.

Later (in 1777) Lavoisier proved that air consisted mainly of two substances, one which suffocated a mouse (nitrogen) and the other which supported combustion (oxygen). He showed that materials undergoing oxidation actually gained in weight, disproving the phlogiston theory. E. Y. K.

SEE ALSO: LAVOISIER, ANTOINE; OXIDE; OXYGEN; PRIESTLEY, JOSEPH

Oxide Oxygen exists alone or is chemically combined with other elements. An oxide is a compound usually made of two elements; one is oxygen and the other usually a metal. Many useful mineral materials are oxides. Ordinary sand is silicon dioxide, SiO_2. Chinese white clay (kaolin) is aluminum oxide; and lime is calcium oxide.

Some oxides are nonmetallic compounds. Our body cells make a gas, carbon dioxide, and slow-burning fuel forms poisonous carbon monoxide.

Mineral oxides are used to obtain the metals with which they are combined in natural ores. The required removal of oxygen, called *reduction*, is technically difficult. In reducing common hematite iron ore (which is Fe_2O_3), carbon monoxide from coked coal is the reducing agent used:

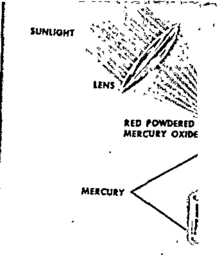
$$Fe_2O_3 + 3CO \rightarrow 2\ Fe\ (iron) + 3CO_2.$$

Aluminum is reduced from its ore, bauxite, by a different method. First, the BAUXITE is treated with soda lye to obtain pure aluminum oxide; this is melted with cryolite ($Na_3Al\ F_6$) and reduced by electrolysis, to yield pure molten aluminum.

Some of the nonmetallic oxides are very unstable. Sulfur dioxide, for example, is the choking gas formed when sulfur burns in oxygen or air. It will react with water to form sulfurous acid. E. Y. K.

SEE ALSO: ELECTROLYSIS, OXIDATION, REDUCTION

Oxyacetylene torch see Acetylene



Lavoisier's experiment showed that a substance (mercuric oxide) can be r reverse its action and release oxygen

Oxygen (OK-si-jen) Oxygen i sidered the most important e for life on this planet. Life can for a while without food or but not without oxygen. Oxy necessary also for fuels to burn.

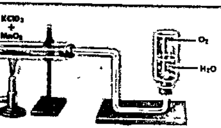
Ancient philosophers did not about oxygen as an element. spoke of "something" in the air bining with fire. Zosimos, an Egy chemist, mentioned this as ear 250 A. D. Oxygen was not sepa as a gas until 1772 when Karl Sc of Sweden discovered it.

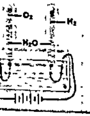
Independently Joseph Priestley had i oxygen but referred to the gas as "de gisticated air." He was surprised to finc a candle burned more vigorously in the

The importance of oxygen was rea neither by Scheele nor by Priestley bu the French chemist Antoine Lavoisier identified oxygen as a material needec combustion. Lavoisier's discoveries laid foundation for modern chemistry.

About 20% of the ATMOSPHERE is m up of oxygen. It is a colorless, odorless, tasteless gas. Its density is .00143 grams cubic centimeter. Oxygen (symbol O) atomic number 8. Its atomic weight is 15.99 Until 1961, it was the standard for the ato weights of all elements: O = 16.000.

Oxygen is found in air as a *diatomic* mo cule, O_2. It occurs in many compou called OXIDES. The most plentiful oxide plain sand (silicon dioxide, SiO_2). La amounts of oxides are found in rocks. iron or aluminum oxides, and as silica





Common laboratory method for preparing oxygen gas (above). Producing oxygen gas by the electrical "splitting" of water (left)

(-SiO_3). Oxygen, next to silicon, is the most abundant element. About 50 per cent of the earth is made up of oxygen.

Oxygen also occurs in compounds called *peroxides*, which contain the peroxide ion. This ion is made of two oxygen atoms joined together by a *covalent bond*. The ion carries two negative charges. A peroxide commonly found in homes is hydrogen peroxide, H_2O_2. Hydrogen peroxide in water is used as a mild disinfectant and bleach. When hydrogen peroxide decomposes, it gives oxygen and water:

$$2H_2O_2 \rightarrow O_2 + 2H_2O$$

Oxygen is usually prepared in the scientific laboratory by the heating of potassium chlorate:

$$2KClO_3 \xrightarrow{MnO_2} 2KCl + 3O_2$$

Oxygen gas is liberated and collected by water replacement. Manganese dioxide is the catalyst in this reaction.

Oxygen is also produced by the electrolysis of water:

$$2H_2O \rightarrow 2H_2 + O_2$$

There are other methods of preparing oxygen. Commercially it is prepared by the liquefying of air. In the *Linde process* air is cooled until oxygen becomes a liquid at −183° C. A few years ago gaseous oxygen was kept in tanks under pressure but today liquid oxygen is kept in tanks as a space-saving measure.

Green plants produce oxygen during photosynthesis in daylight. Plants must use some oxygen from the air to carry on their own respiratory processes.

The ability of oxygen to support combustion, called *oxidation*, is its most significant property, and oxidation reactions always yield energy such as heat or light.

Tank oxygen is used in treating pneumonia and heart trouble. It is also used in flying, in submarines, in deep-sea diving, and in oxygen torches. E. Y. K.

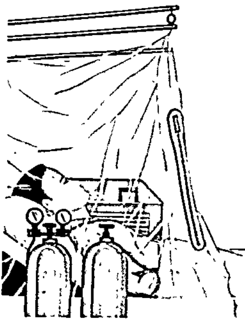
SEE ALSO: COMBUSTION; ELEMENTS; LAVOISIER, ANTOINE; OXIDATION; PRIESTLEY, JOSEPH; SPONTANEOUS COMBUSTION

Oxygen tent An oxygen tent is a piece of medical equipment used for people with illnesses in which the body cannot get enough OXYGEN from air. The condition in which the body tissues are without oxygen is called *anoxia*.

Oxygen tents are of various designs Essentially an oxygen tent is a material which can retain an oxygen-enriched air mixture about a patient. It may be dome-shaped or box-shaped, with various arrangements of openings to allow for passing food and medication to and from the patient.

An oxygen tent enables a patient to get more oxygen per inhalation than he normally does A tank of liquefied oxygen serves as the oxygen supply. If respiration is weak, each inhalation must be rich in oxygen to compensate for the small air quantity inhaled. Various conditions require differing mixtures D. J. I.

Oxygen tent



J. W. Thomson

Japanese oyster

Oyster The oyster is a small sea animal enclosed in two hinged shells called *valves*. Oysters belong to a group of mollusks called *bivalves* (two-valves). Varieties are used for food, mother-of-pearl, and PEARL production. Oysters are found mainly in waters off sea coasts.

The full-grown oyster's shell is the size of a woman's hand, appearing grayish colored and irregularly pear-shaped. One valve is larger and cupped, holding the animal's soft body. The other is like a lid on a box. The inside of the valves is made smooth by a secretion of the oyster. This is "mother-of-pearl." Its smoothness protects the soft, naked animal. The valves open and close slightly, controlled by adductor muscles, located on either side of the body. Oysters breathe by GILLS and eat minute plants and animals in the water. To remove an oyster, one must force the shell open by cutting the strong muscles at the hinge with a sharp knife.

Oysters develop from eggs, one oyster producing hundreds of millions of eggs in a season. This large number of eggs is vital, for quantities are eaten by fish, which also devour the larvae (small swimming forms which develop into adults. These swimmers travel about for two weeks until they anchor permanently. They continue to grow, arriving at full growth in three to four years.

Commercially, oyster "beds" are kept in favorable condition for oyster production and development. Since oysters live such perilous lives, "farmers" must do all they can to guard their investment by careful attention to oyster needs. D. J. I.

SEE ALSO: MOLLUSCA

Salsify, with its oyster-flavored root

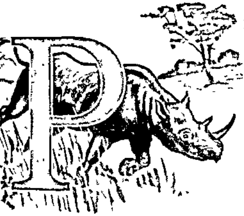
Oyster plant The oyster plant has row leaves and large yellow or pu flowers. There are several vari which grow wild in Europe. The *s fy*, or purple goatsbeard, is grow the United States for its edible, oy flavored root.

Ozone (OH-zohn) Ozone is a form OXYGEN. It is different from ordin oxygen in that the molecule cons of three atoms of oxygen instead two. It is a bluish GAS that can formed by passing an electrical charge through oxygen. Thus LIG NING is a natural means of produc ozone. Ozone can be produced r chanically by passing air betw highly-charged electrical plates of special machine. Ozone is also form by the arcs from electric mo brushes, and can be identified by t rather penetrating odor associat with running motors.

In the upper ATMOSPHERE, ozone is p duced when ultraviolet sunlight strikes ox gen. Because these rays are harmful in gr amounts, it is advantageous that they a absorbed. The ozone which is produced the upper atmosphere is wafted downwa by *convection* currents. Only minute qua tities are in the atmosphere man breathe however, and in small amounts this poiso ous gas gives an invigorating touch to t air and can be tolerated.

Ozone is chemically active because th extra atom of oxygen is loosely held an combines readily with substances. It is use for certain cleaning and purifying processe D. J.

Ozonosphere see Atmosphere



Pacemaker see Heart

Pachyderm A pachyderm is a thick-skinned, hoofed animal such as an ELEPHANT, RHINOCEROS, or HIPPOPOTAMUS. Cud-chewing animals (ruminants), such as cattle and goats, are also hoofed but are not pachyderms.

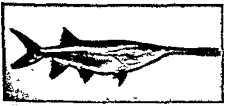
The pachyderm group is a popular group rather than a scientific one. Taxonomically most pachyderms are not even classified in the same order of mammals and are not closely related. For instance, the hippopotamuses are more closely related to cattle than to elephants, and yet cattle are not pachyderms. J. C. K.

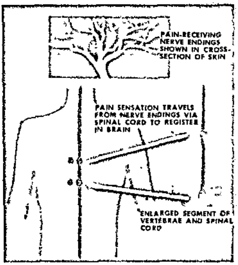
Pacific Ocean see Ocean

Paddlefish The paddlefish, or duckbill, is a freshwater fish found in the Mississippi River and its branches. It is scaleless, and sometimes reaches a length of six feet and a weight of 150 pounds. It is related to the sturgeon, and its eggs are often mixed with eggs of the sturgeon for caviar. Another species of paddlefish is found in large rivers of China.

Paddlefish

Chicago Natural History Museum





Pathway of pain sensations through the spinal cord, and cross-section of skin showing finely-divided pain-receiving nerve endings

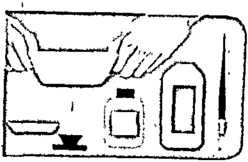
Pain Pain may be defined as suffering or distress in the body. Most animals, as well as people, can feel pain. Pain is one of man's oldest enemies, and man tries hard to avoid pain whenever possible. Pain is also a great friend of man, however, because it is the body's way of reporting DISEASE, INFECTION, or injury of certain body parts. A person who can feel no pain lives a life of constant danger. Such a person might even die because of an infection he did not find out about in time to see a doctor.

Most pain is detected in the body by thin, bare, and finely-branching nerve endings in the skin and internal organs of the body. These pain receivers are like a very finely-divided electric wire. Feelings of pain are carried as tiny electric impulses along the nerves up through the spinal cord to the brain. Pain is a very personalized sensation. Intensity of pain varies greatly in different persons and even in the same person at different times. No one can really know the intensity of pain felt by another person. Man has made great progress in his battle against pain. Doctors today have over 1,000 different pain killers, or *analgesics*. R. S. C.

SEE ALSO: NERVE CELL

✳ THINGS TO DO

CAN YOU MAKE A BLACK PAINT?



1 For making homemade black paint you need carbon or lampblack, turpentine, and linseed oil.
2 Lampblack can be obtained by holding a pyrex dish or bottle over a candle flame until the carbon forms on it. Scrap the film of black into a small amount of linseed oil.
3 Mix these materials thoroughly. Add a few drops of turpentine to make the paint thin enough to spread on a surface. The result will be a flat permanent paint. Shiny enamel paint is obtained by adding a few drops of varnish to the flat mixture.

Paint Paints have been used through the ages to decorate surfaces and to protect them from sun, water, or heat. Artists use paints to create beautiful pictures. Children use various paints to make murals and pictures.

One of the most important uses of paint in modern times is that of protecting surfaces. Wood is an excellent building material, but it quickly rots if left exposed to the weather. Special outdoor paint is used to paint wood exposed to sun and rain. Indoors, paint is used to beautify wall surfaces, to make them easier to keep clean, and to increase or decrease light reflected from the walls. Special purpose paints include anticorrosive paints to keep iron and steel from rusting; marine paints to keep boats shipshape; fireproof paints, used where fire is a hazard; luminous paints which glow in the dark; and poison paints, used to keep parasites from attacking wood.

All paints basically consist of a containing a pigment. The *pigmen* coloring material of the paint. The not only determines the color but a opaque the paint will be. The less the paint, the more paint needed to given surface. The *vehicle* is the which holds the pigment. It is the which dries and forms a film, hold pigment particles together and onto a Oil and water are the vehicles mos monly used.

Oil paints consist of a pigment in vehicle. The vehicle usually has botl tile and nonvolatile components. The portion of the vehicle, usually a thinne as TURPENTINE, makes the paint eas apply and speeds drying by its evapo from the paint. The dried paint film, ever, contains none of the volatile p of the vehicle. The nonvolatile porti the vehicle is often called a *binder* be it binds the pigment particles together.

Water paints are those paints whicl water, rather than oil, as the medium. are used as house paints because they economical, fast-drying, and easy to and apply. Calcimine paints and white contain animal glue for a binder. C paints contain milk casein as a binder. newer resin emulsion water paints (l paints) use a synthetic resin as a bin They are easier to apply than either ca mine or casein paints and may be app with a roller.

Enamels are a type of paint in which pigment is mixed with varnish, rather t with an oil. Enamel gives a high gloss ish and is much easier to clean than oil paint, which is often referred to as paint. *Lacquer* is similar to an enamel l has a glossier finish and is harder. D. L.

SEE ALSO: PIGMENT, VARNISH

Painted cup see Wild flowers

Palate The palate is the roof of tl mouth. The front part, called the *har palate* is bony and hard; and the bac portion, called the *soft palate* is mu cular and soft. Both are covered wit MUCOUS MEMBRANE. They separat the mouth and the nasal cavity.

Paleolithic see Stone Age

Paleontologists may first make ground surveys of an area which is likely to hold fossils. Then, when a fossil is found it must be removed from the ground very carefully. The rock around it may be useful in dating the specimen

Paleontology (pay-lee-uhn-TAHL-uh-jee) Paleontology is the science that deals with *fossils.* Fossils are the remains of plant and animal life from thousands of years ago. Paleontology is often considered to cover just fossil animals, but a better division of this science is to use *paleozoology* for the study of fossil animals and *paleobotany* for the study of fossil plants. "Paleo" is from the Greek word *palaios,* meaning "ancient."

Fossils are useful as evidence of evolution. A collection of them may show the changes that a certain kind of animal has gone through. Fossil bones of early man found all over the world show the story of the changes from ape to modern man. These changes took almost two million years. As a general rule, paleontology usually does not deal with things less than 10,000 years old.

Paleontology is closely connected to GEOLOGY, the study of the earth's crust, including the sediment at the bottom of the ocean. Impressions such as footprints of past animals are often found in rocks. Though a fossil is rock, when the animal left an impression the surface was probably moist sand or clay. Physical changes on the earth's surface determine whether or not remains will be preserved as fossils.

Fossils tell the geologist much about the earth. He may want to know how old a rock is. If the rock contains fossils of animals that he knows lived only about 100,000 years ago, he can be fairly sure that the rock is about 100,000 years old. Such fossils are called *index* fossils.

6824

HISTORY OF PALEONTOLOGY

G62

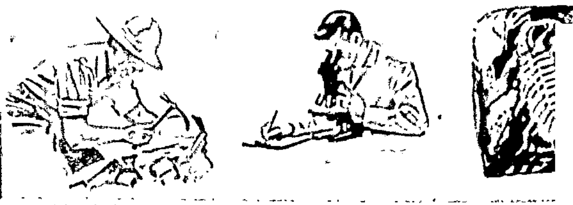
The first notice and scientific interpretation of fossils was recorded by the Greek Xenophanes in 600 B.C He observed fossils of mollusks inland, away from the sea, and thought that the sea had once covered that area. In Egypt one hundred years later, Herodotus observed shells in the desert and tried to interpret them.

Not until the beginning of the scientific renaissance in Europe, about 1400 A D, did fossils again come to be considered as evidence of changes on Earth. Leonardo da Vinci was the first expert since the classical times of ancient Greece to recognize fossils without superstition About the same time, they were mentioned in a scientific book by the geologist Agricola.

Modern paleontology started about 1800 from the work of two men—BARON GEORGES CUVIER and William Smith Smith found that in different layers (strata) of rock, different fossils were found. His work started *stratigraphical* geology and, in large part, had a basis in the use of index fossils Cuvier, however, studied fossils in the same way that zoologists and anatomists study living things. He tried to interpret the habits and environments of past animals from their fossil structures. The work of these two men brought about the first division of general paleontology into separate areas

FIELDS OF PALEONTOLOGY

Paleobiochemistry· A very specialized field of paleontology is paleobiochemistry. This area of study is confined to studying fossils for remnants of organic compounds Workers in this area of biochemistry have been able to identify amino acids in fossils up to 360,000,000 years old. These scientists know that the older the fossils are, the fewer amino acids remain.



When the fossil is recovered, it may be gently scraped or bathed in acid and fixed so it c studied or displayed without damaging or destroying it

Paleobotany: The study of fossil plants and vegetation has become very important for a knowledge of environmental conditions in the geologic past. Paleobotany has been, and is, vital to a clear scientific description of the evolution of plant life on earth.

Evidence of the *angiosperms* (flowering plants which now dominate the earth) are found only in deposits made after the middle of the Mesozoic Era. The *thallophytes* (algae and seaweeds), on the other hand, have existed for more than 500 million years. There are eleven large groups of plants which are known only in fossil form, as the dinosaurs are known. The most dramatic plant fossils are the giant logs of petrified wood.

Collecting plant fossils is more difficult than collecting animal fossils because of the delicate plant structures that are so easily destroyed or carried away by water. Leaf deposits are often found in thin layers of fine sediment. Usually only impressions will be found because moisture caused the leaf to decay. Some fragments, though, will have been *carbonized* and are more easily preserved.

Paleoclimatology: Paleoclimatology is part of paleogeography. It deals with winds, precipitation, weather, and climate zones of past geologic ages. The study is based on rocks and organic remains.

For example, if fossils of what are now tropical plants are found in a far north region where such plants could not now grow, there may be two explanations. Either the climate of the region changed greatly, or the earth's crust itself shifted into a different climate zone. The way in which sediments hardened into rock also shows varying climatic conditions. Past conditions in the ocean can be interpreted by the presence of coral reefs and other fossil organisms. The mammoths found in Siberia is one of the greatest challenges to paleoclimatologists. It is difficult to explain how such a hug mal as the mammoth could be froze stantaneously, with undigested food st its stomach.

Paleoecology: The ecology of fossil is a more difficult study than the ECOLOC living things. Because of the vast geol changes, the science has to be based o ferences. Its basic assumption is that pl and animals in the far past formed an i related and balanced society much as the today. Most data are in the area of ma biology, because more fossils are foun marine sediment than are found on lan in fresh water.

Paleogeography is primarily concer with the geography of the past and d with fossils only in describing areas.

There are several other terms that fall i the general field of paleontology. *Paleo nology* is the study of the races, cultures, specializations of prehistoric man. *Pale tography* is the straight physical descript of fossils.

COLLECTING FOSSILS

Searching for fossils can be an interest hobby or career. They may be found ac dentally, but it is necessary to have so general knowledge of geology and zool to understand what they are. On discoveri fossils, it is important for the amateur note carefully the kind and location of roc they were found in. The fossil can som times be identified with the help of the ro type. If the rock cannot be easily identifie the amateur should take careful note of t location so that an expert can identify it.

An experienced paleontologist may able to compare the fossil find with oth fossils and with living things. For this knowledge of biology is vital. J. F.

SEE ALSO: BALANCE OF NATURE, CLIMAT EARTH, ECOSYSTEM, EVOLUTION OF MA FOSSILS, GEOLOGIC TIME TABLE, PETRIFA TION, ROCKS, SOIL TYPES, TRILOBITE

Chicago Natural History Museum
Corals of the middle Cambrian life

Chicago Natural History Museum
Marine invertebrates of the late Ordovician

Paleozoic Era (pay-lee-uh-ZOH-ick) The period of ancient life called the Paleozoic Era began about 500 million years ago and came to an end about 200 million years ago. Great changes in life took place throughout this era.

During this 300 million years many changes occurred, with a progression from the Age of Invertebrates to the Age of Fishes and the Age of Amphibians. During this era came the first vertebrates, land animals, insects, plants, forests, and seed-bearing plants.

The Paleozoic Era also saw a variety of climates. During long periods of warm dry temperatures, great deposits of salt were formed. There were also periods of warm humid climate in which vast coal-forming swamps came into existence. There were periods of very cold climate when huge glaciers covered the earth.

There were seven recognized periods that made up the Paleozoic Era. They are named after places where rocks of the period were first studied. Listed in order of occurrence they are: Cambrian, Ordovician, Silurian, Devonian, Mississippian, Pennsylvanian, and Permian. European writers refer to the Mississippian and Pennsylvanian periods together as the Carboniferous, or coal-forming, Period. The Appalachian revolution took place during the Paleozoic Era and resulted in the creation of the Appalachian Mountains near the close of the era.

There were many changes geographically during this period of ancient history. Large inland seas were formed when rising ocean waters flooded interior areas of North America. At other times uplifting occurred, the seas receded, and mountains may have been formed. These inland seas of the seven periods of the Paleozoic Era differed considerably in extent and location. There was no regular pattern or sequence to their origin and disappearance. Some existed for very long periods of time, while others were of shorter duration. Some formed at the start of periods, others in the middle or at the end. The three largest inland seas occupied broad shallow depressions known as the Appalachian Trough, the Cordilleran Trough, and the Ouachita Trough. The Appalachian Trough was located roughly where the Appalachian Mountain chain is today. The Cordilleran Trough occupied the Rocky Mountain area of today. The Ouachita Trough stretched from across Oklahoma to Texas and New Mexico.

This was an era of many changes. There were many beginnings, evolutional processes, and endings during the era known as the Paleozoic Era. V. V. N.

SEE ALSO: GEOLOGIC TIME TABLE

Palladium (puh-LAY-dee-um) Palladium is a metallic element. It has a bright silvery luster. This rare, grayish element is less dense, a little harder, and more easily oxidized, than platinum. It is found in platinum, nickel and copper ores.

Pure palladium is used in the manufacture of mirrors and watch springs. It is also used in alloys with gold, platinum, and silver. These alloys are used for jewelry, dental equipment, picture frames, pocketbook trim, and scientific instruments.

Palladium (symbol Pd) has atomic number 46. It has an atomic weight of 106.4 (exchanged from oxygen). It was discovered in 1804 by William Wollaston. M. R. L.

SEE ALSO: ALLOY, ATOM, ELEMENTS

From left to right royal palm of Africa, flower of the date, palmetto—a small tropical American pa and Travelers palm of Africa

Palm There are about 2000 kinds of plants in the palm family. They range in size from small house plants to trees up to 100 feet tall. They are found in tropical areas. The trunk usually has no branches. The small flowers are either male or female blooms. The fruit is a drupe or berry.

Palms belong in the *monocotyledon* subclass of angiosperms. The leaves may be pinnately compound as in the DATE palm, or palmately compound as in the fan palm. The stem may be spiny, smooth, or covered with stumps of old leaves.

Economically, palms are important to man. The COCONUT palm's rating is near the top. The natives have found over 800 uses for the *Palmyra palm. Royal palms* withstand strong winds and are popular ornamental trees in Florida. The *American oil palm* produces 2000 nuts annually for 50 years. The *cohune palms* of South America also yield an oil.

The pith of certain palms gives *sago* starch. The buds of *cabbage palms* are eaten. Leaves of the *hat palm* are dried, bleached and woven into hats. The *tagua palm* seed furnishes a vegetable ivory for buttons and dice. The epidermis of the *raffia palm* leaf is woven into baskets. Wax from *carnauba palm* leaves is used in varnish. H. J. C.

SEE ALSO: MONOCOTYLEDON; PLANTS, TROPICAL; RAFFIA

Palmate venation see Leaves

Palsy see Paralysis

see South America

anama Canal see South America

Pancreas (PAN-kree-uhs) The pa creas is a gland shaped rather like fish. It is found in the abdomens animals with backbones. The pa creas plays a double role in the bod It produces *enzymes* needed to dige all kinds of food. Small sections of th pancreas, called the *islands* (or *islets* of *Langerhans*, produce a *hormon* that enables the body to use sugar.

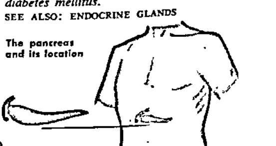
The human pancreas is about six to nin inches long and an inch and one-half wid It lies behind the stomach and a little belo it. The right end of the pancreas is folde forward around a group of blood vessel This hook-like piece is called the *head*.

The digestive juice is collected in a duc that leads from the pancreas to the duo denum.

INSULIN is the hormone produced by tissues in the pancreas. Unlike the digestiv juices, it is a ductless *(endocrine)* secretior and enters the body through the blood vessels. It is called *insulin* from the Latin word *insula*, meaning *island*, because it is secreted by the islands of Langerhans. If they do not make enough of it, the body cannot burn sugar. This condition is called *diabetes mellitus*. D. A. B.

SEE ALSO: ENDOCRINE GLANDS

The pancreas and its location



Courtesy Society For Visual Education, Inc.
Giant panda

'anda The giant panda is one of the arest of large mammals. It looks like giant black and white toy bear. Acually, it is not a bear at all but a relaive of the RACCOON. It is very playful vhen young but can be dangerous vhen grown. It reaches full growth in bout five years and then can weigh s much as three hundred pounds.

Another type of panda is called the *lesser* anda. It measures less than four feet from s nose to the tip of a ringed, raccoon-like il. The Chinese call it *fire cat,* because f its rusty-red hair. When angry, it spits nd hisses like a cat and can inflict severe juries with its sharp teeth and claws.

Pandas are found only in mountains of estern China. The lesser panda has long een known, but the giant panda was condered a myth until a hundred years ago. he first live giant panda was captured in 937. Few have lived in captivity. J. A. D.

andanus Pandanus is a large family f two hundred tropical trees and rubs, called *screw pine*. The name omes from the spiral manner in hich the leaves are arranged. They e easily raised as potted plants in omes or greenhouses. They need ndy loam mixed with charcoal and af mold, plenty of water, good ainage and partial shade in summer. ften the downward course of the ots will raise the plant out of the ot. Some of the roots raise above the il and are called *prop roots*.

Pandanus, or screw pine

Courtesy Society For Visual Education Inc
Pansies

Pansy The pansy is probably one of the oldest cultivated plants. It is related to the VIOLET. For at least 400 years, the pansy, which is native to Europe, has taken to all cool, temperate climates of the civilized world

The pansy is a low-growing plant, seldom more than six inches tall It has heart-shaped leaves and large, irregular flowers that look like human faces The blossoms may be purple, white, blue, yellow, brown or a mixture of these colors

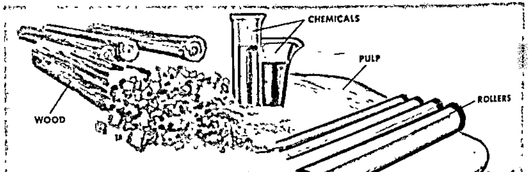
Pansies should be grown in partial shade and given plenty of moisture. When the air becomes dry during the hot summer months, the pansy plant is apt to fail even though it may be in the shade Some pansies are annuals; some are perennials J K K

Panther see Cat family

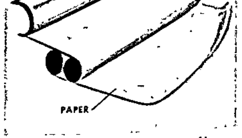
Papaya (puh-PAH-yuh) Papayas are herbs that are sometimes called *pawpaw trees*. Papayas grow in tropical America. They are about eighteen feet tall and look like palm trees. They have a cluster of huge leaves on top. Papaya fruits ripen in midwinter or early spring. They taste somewhat like muskmelons. They are yellow or orange and weigh as much as twenty pounds. Papaya fruits have a strong odor.

The unripe fruit is cooked like squash The milky juice and black seeds inside the fruit are rich in papain *Papain* is used in medicine and as a meat tenderizer Papayas need sunshine, well-drained, rich loam, and frequent cultivation. M R. L.

Papaya tree and fruit



Paper The discovery of paper contributed greatly to civilization. Writings have been traced back thousands of years to a time when signs and words were made on bark, bricks, skins, and other surfaces.



The main processes in paper-making

If man had observed nature and watched paper-making wasps use wood pulp, he might have made paper earlier. The wasps chew the pulp and spread it in thin layers to form the walls of their nests.

Today there are about five thousand different types of paper with almost as many uses. The consumption of paper in the United States is enormous. Over four hundred pounds per person are used in a single year.

Paper is made from CELLULOSE or vegetable fibers. In the early days of paper-making, rags were the chief source of fiber for paper. Today the chief source of cellulose for paper is wood. When the forests were abundant, preferred woods were selected. Today, many kinds of wood are used for pulp, including pine, spruce, hemlock, fir, poplar, beech, birch, maple, and aspen.

Many successful experiments have been made to produce paper from fibrous materials other than wood. But while the supply of wood lasts, it seems to be the easiest and most economical pulp material. Paper has been made from hemp, turf, moss, potato skins, tobacco waste, coconut husks, bean stalks, cabbage leaves, bamboo, and many other vegetable materials. The important considerations for pulp material are the need for long enough fibers to make strong paper, the ease of changing the material to fiber form and eliminating impurities, availability of large supplies of low cost material, and economical means of getting the pulp materials to the mills.

If a sheet of medium-weight paper is held up to a good light, the paper can be seen to be made up of small fibers matted together. The logs that arrive at a pulp mill have to be reduced to these small fibers. One of the methods used is mechanical, the others are chemical. In the mechanical, or ground-wood method, pulp is produced by grinding the wood with grindstones under water. The chemical process takes wood chips that have come through a chipping machine, combines them in a digester, an enormous pressure cooker, with chemicals and cooks them to pulp. Different chemicals are used depending on the kind of wood used and the kind and grade of paper desired. There are sulfite (acid), sulfate (alkaline), and soda processes used in chemical methods.

The pulp, which is about 95 per cent water, is usually bleached and then goes to the paper machine. The pulp is spread onto a screen-like bed, which moves forward as it drains off some of the water and jostles from side to side to mat the fibers. The pulp is rolled between felt rollers to absorb moisture and pressed and dried as it goes through a series of rollers. The continuous sheet emerges and is wound in large rolls as finished paper to be used in manufacturing paper products. C. L. K.

SEE ALSO: FOREST PRODUCTS, PAPYRUS, PRINTING

Red pepper, or capsicum, plant

Paprika Paprika is a spice made by grinding the dried pod of the red pepper, or *capsicum*, plant. It is a reddish powder, sweeter in taste than CAYENNE or chili pepper. It is often used for decorating foods such as mashed potatoes or creamed chicken.

The capsicum plant belongs to the NIGHTSHADE family and is not related to the *Piper nigrum* plant from which black and white pepper are made. The capsicum plant is an annual shrub bearing small white flowers and reddish oblong fruit which stands upright on the branch. These pods are called *pimiento*. J. M. C.

SEE ALSO: PEPPER, SPICE

Papyrus (puh-PY-ruhss) Papyrus is a tall reed-like plant that lives in wet places. It was used by the ancient Egyptians, Greeks, and Romans to make a writing material like paper. The word "paper" comes from the word "papyrus."

The Greeks peeled thin strips from the papyrus stem, pasted or pounded the strips together, smoothed them with shells, and rolled the sheets into scrolls.

Papyrus was also used for making boats, rope, sailcloth, and mats. The roots were used for fuel and the flowers for decorating the shrines of gods. Today, the plant is quite rare and usually found only as decoration in water gardens. J. M. C.

SEE ALSO: PAPER

Papyrus plant

Paracelsus

Paracelsus, Philippus Aureolus (pair-uh-SELL-suss) (1490-1541) Paracelsus was a Swiss physician and alchemist. An alchemist was a medieval chemist who attempted to prolong life indefinitely, to discover a universal cure for diseases, and to change common metals into gold. As a physician, Paracelsus preceded SIR JOSEPH LISTER in maintaining "All that is necessary [to heal wounds] is to prevent infection in wound diseases."

Paracelsus was born near Einsiedeln, Switzerland. He received his early education from his father who was a physician and chemist. He studied at the University of Basel, but left without getting a degree Traveling to the mines in Tyrol, he studied the mechanical problems of mining, composition of minerals, and diseases of miners

When he returned to lecture at the University of Basel in 1526, Paracelsus was met by intense opposition. His books in which he set forth his theories and methods of treating disease were burned by his enemies before he could begin his series of lectures

He also lectured in German instead of Latin, the language of scholars, which was an inexcusable breach of their scholarship

His opponents declared that his ideas had serious defects and that he did not have a degree. Finally, feeling became so heated that Paracelsus was forced to flee Basel He wandered from place to place until 1541 when Archbishop Ernst invited him to live in Salzburg and offered him protection. However, his security lasted only a short time, for on September 24 of that same year Paracelsus met a tragic and brutal death at the hands of his enemies when he was thrown down a steep incline. D. H. J.

SEE ALSO: ALCHEMY, MEDICINE

THINGS TO DO

WHY DOES A PARACHUTE MAKE AN OBJECT DESCEND SLOWLY?

1 **Go outside in an open area and throw a ball as high as you can. Observe how fast the ball returns to the ground.**

2 **Now tie a network of strings around the ball. Attach four long strings to four sides of the ball by tying them to the net. Tie the other ends of the strings to the corners of a two-foot square of cloth. Wrap the lines and parachute around the ball.**

3 **Again throw the ball as high as possible. Does the ball descend at the same rate of speed? Any falling body must push aside the resisting air. Since the parachute encounters a much greater area of air, it falls more slowly.**

THINGS TO DO

DO OBJECTS OF THE SAME WEIGHT FALL AT THE SAME SPEED?

1 **You will need two sheets of ordinary typewriting paper approximately the same in size and weight for this experiment. Leave one as it is; wad the other tightly into a ball.**

2 **Stand on a chair for added height. Stretch arms and hands straight out in front, palms up. On one palm is the paper ball, on the other the flat sheet of paper. Quickly pull your hands away, letting both objects fall to the floor. Try timing the two descents with a stop watch.**

3 **What fact about the papers would account for the results you obtained?**

E.M.N.

Parachute The parachute was invented to allow men to escape from AIRCRAFT above the earth. Today it is also used for dropping cargo to places difficult to reach in other ways—cargoes of food and medicine and perhaps kits of fire-fighting tools. Fast planes may use parachutes to help in stopping or braking while landing.

An open parachute looks like a huge stickless umbrella. Closed or folded into a bundle, it looks like the pack of an overnight camper.

Any falling object has two main forces acting on it: the pull of *gravity* and the *resistance of the air.* GRAVITY, the stronger of these forces, accelerates a man in free fall to about 120 miles per hour when falling at lower altitudes. The broad-surfaced open parachute increases the air resistance, assuring a slower, safer rate of descent.

Once away from the aircraft, the falling parachutist pulls the *ripcord,* releasing a small *pilot chute* of about three-foot diameter. This catches the airstream and pulls out the larger, *main chute* or *canopy* which may be 24 feet in diameter. Spaced evenly around the canopy's edges are about 36 long ropes or *shrouds,* connected to the harness worn by the parachutist. A hole or vent in the top of the canopy stabilizes the canopy's descent by letting some air escape. Fast modern craft, such as jet fighter planes, have ejection seats so that the pilot can, by exploding a gunpowder device, be thrown clear of his aircraft and then open his chute to come down safely.

The parachutes of today are made of NYLON which has great strength and flexibility.

The parachute idea has long intrigued men. Leonardo da Vinci in 1514 and Fausto Veranzio in 1595 worked out such devices on paper. But the first successful chute jump was made in 1797 by the French balloonist, André Garnerin. More than ten years earlier, the physicist Lenormand had practiced jumps from a high building.

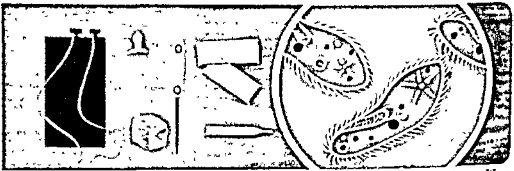
R. J. J.

Paraffin (PAHR-uh-finn) Paraffin is a colorless, odorless, tasteless wax made from petroleum oil. It is used for sealing jars of jelly and for waxy coating of milk cartons.

SEE: HYDROCARBONS, PETROLEUM

THINGS TO DO

HOW DO PARAMECIA REACT TO THEIR SURROUNDINGS?



1. Paramecia may be obtained from a supply house or from a homemade culture (see PROTOZOA). Place a few drops of the solution they come in on a glass slide. Put a few minute crystals of carmine in the edge of the drop of water.
2. Place the slide on a microscope and bring the paramecia into focus. A powerful hand lens will work almost as well if a microscope is not available. Observe the paramecia as they approach the crystals. The movement of the cilia causes them to roll, go forward and to back up.
3. Continue to experiment with different materials, starting each time with a fresh culture on the slide. Place a small chip of ice in one place in the drop of water. Which way will the paramecia turn? Cover one-half of the slide to eliminate the light. Do they prefer darkness? Connect a wire to each terminal of a dry cell. Touch the exposed ends of the wires together in part of the solution. A very slight current will be discharged. Can these little one-celled animals respond to an electrical charge? Paramecia, though lacking a nervous system, are still very responsive to their environment.

temperature for two to three days. The scum which forms on the surface will contain dozens of paramecia.

The paramecium's shape never changes. Its front end is blunt and its posterior pointed. About one-third of the way from the front is an oral groove lined with cilia. This groove ends in a *cell pharynx*. Bacteria, the paramecium's food, are swept into the mouth by the cilia in the groove and are enclosed in a bubble-like structure called a *food vacuole*. Digestion occurs in the vacuole as it moves in a set pattern through the cell. Undigested material is discharged from a point at the end of the cell called the *anal pore*.

The paramecium has two nuclei, the larger called the *macronucleus*, the smaller, the *micronucleus*. The micronucleus controls reproduction, the macronucleus, all other functions. *Trichocysts*, small glassy rod-shaped bodies just below the surface, are used for defense and for anchoring the animal. The cilia move food in and move the animal forward. Cilia are connected by threads inside the body, and beat in unison like many small oars. The paramecium avoids objects in its path by trial and error. When it strikes an obstacle, it backs up, changes direction and tries again. A contractile vacuole forms every ten to twenty minutes to expel excess water from the cell.

The paramecium divides crosswise, by mitosis, after the nuclei divide and a second cell pharynx buds off. *Conjugation*, a simple form of sexual reproduction, can also take place. Two paramecia lie with their oral grooves touching. The macronuclei of each disintegrate; the micronuclei of each divide twice, forming four micronuclei. Three disintegrate and one divides into stationary and migratory nuclei. The migratory nuclei are exchanged and unite with the stationary nucleus of the other cell.

The individuals separate and each divides to form four new individuals. J. K. L.

SEE ALSO: MITOSIS and MEIOSIS; REPRODUCTION, ASEXUAL

Parasites A host is a person who allows guests to share his home and food. Although most guests are pleasant, some can be very selfish. Those which take all that they can from their host are called *parasites*. Many plants and animals are parasites which feed upon other living plants and animals. They accept food and a home from their host. In return they offer only sickness and disease.

Houses for people are large enough to permit many kinds of plants and animals to live together. In one house there may be ants, geraniums, dogs, molds, moths, and people. To most parasites the body of the host is as large as a building. Parasites are always smaller than their host. Many cannot be seen except under a microscope. Thus, many thousands of parasites may live in one host.

Parasites often choose to live inside other parasites. A virus may live in a bacteria, which lives in a worm, which lives in a dog. One dog may be host to many kinds of parasites.

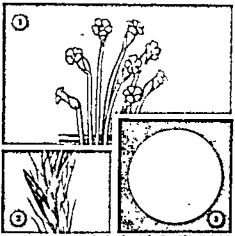
The word *parasite* really means "alongside food." Parasitism is concerned mainly with the problem of obtaining food. Certain plants and animals have found it easier to become parasites than to compete for food. Organisms which feed upon other plants and animals do not always find quantities of food. Parasitism flourishes among viruses, non-green plants, and animal groups.

PARASITIC PLANTS AND ANIMALS

A true parasite feeds only upon living plants and animals. Plants which feed upon dead or decaying matter are called *saprophytes*, while animals which feed upon dead organisms are called *scavengers*. A few parasites, like the blue-green mold on the orange, are able to live upon either dead or living hosts. Green plants, which contain chlorophyll, like the mistletoe, are able to manufacture part of their own food. Since they cannot manufacture enough food, they become *semi-parasites* upon larger plants.

There are parasitic members of nearly all phyla of both plants and animals. Many plant parasites are found among the *bacteria*, *slime molds*, and *true fungi*. Diseases of man, such as tuberculosis and pneumonia, as well as rots and galls of plants are caused by bacteria. Several molds cause infection of animals. Aquarium goldfish are often killed with water mold, while man may develop skin diseases caused by black mold. The fungi cause damage to higher plants by producing rusts, mildews, smuts, and rots. Such diseases as potato blight, Dutch elm disease, and apple scab result from attachment by these parasites. In man, ringworm and athlete's foot, caused by the same organism, are fungous diseases.

Animal parasites attack almost every species of animal. Parasitic species number in the tens of thousands. The greatest number of parasitic animals are found among the *protozoan*, *flatworm*, *roundworm* and *arthropod* phyla. In man, yellow fever, sleeping sickness, and amebic dysentery are caused by members of the *Protozoa*. The fluke, tapeworm, trichina, and filaria are a few of the parasitic worms that cause disease to many higher animals. By sucking cell sap, some roundworms cause wilting and gall in plants. Lice, mites, and ticks are well-known parasites among the arthropods. With greater powers of locomotion, higher animals are better equipped to compete for food. Only a few, such as the LAMPREY eel, adopt parasitic habits.



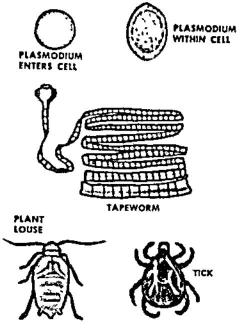
Courtesy Society For Visual Education, Inc.

1—Concerroot, a parasitic plant, lives on the roots of other plants

2—Ergot on rye is also caused by bacteria

Photo-micrograph by National Teaching Aids, Inc.

3—Pneumonia bacteria is a parasitic plant that may live in man



Some common parasites

METHODS OF ATTACK AND DEFENSE

A soldier in the army must have special equipment to invade the enemy camp. In the same way, all parasites must have special body parts to enable them to live as unwelcome guests within the host. Each species has its own equipment for attack.

Those which attach themselves to the outer surface are called *outer* or *ectoparasites*. Animals like the leeches, mites, and lamprey eels, which cling to skin or hair, have developed suckers and hooks. Many have cutting, biting, or sucking mouth parts. Plants like the molds, fungi, dodder, and mistletoe have rootlike structures called *haustoria* which pierce the outer tissue of the host and draw nourishment from the inner cells.

Plants and animals which live inside the body of the host are called *inner* or *endoparasites*. They must have defenses against digestive juices, antibodies, white blood cells, and acids. Those like the viruses, bacteria, and fungi which move into the cells and feed directly upon the cell protoplasm develop thick outer coverings. Parasitic worms have thick cuticles, while many have additional hooks and suckers. Endoparasites often produce enzymes which break down the tissue and provide a pathway for movement.


The leech has suckers which cling to sl

Since the body changes in function, n parasites are no longer able to live inde dently. Many adults lose important l parts. The tapeworm, for example, lose digestive, muscular, and nervous syst One parasitic barnacle loses its shell that it no longer resembles a barnacle.

Since parasites do not have to w about locomotion, digestion, or protect they are able to concentrate all their eff upon reproduction. Most of them have w developed reproductive systems and are a to produce quantities of young. One fl for example may produce thousand of eg However, parasites must be prolific sir many of the young never reach the pro host.

MOVEMENT FROM HOST TO HOST

Many animal parasites are able to mo freely, either in the larva or the adult sta For example, the larva of the hookworm free to move to find a host, while the adu is completely parasitic. But organisms lil the bacteria, viruses, and molds must re upon wind, water, or an intermediate ho like the mosquito to transfer them fro host to host. These organisms lack the pow of locomotion.

Many parasites need to have two or mor hosts in order to complete their life cycle Since they alternate in order from one hos to the next, this method is called *alternatio of host*. They rely upon both food chain and physical agents like wind, air, an water.

The wheat rust has two hosts. Carried by the wind, the spores are passed to the barberry, where they undergo development. The Chinese liver fluke has two intermediate hosts. The adult, which lives in the liver of

man, sheds eggs into the intestine. These are passed with the feces to the ground. After being eaten by a snail, they are able to develop into larvae which swim through the water, find a fish, and settle in the muscle tissue. Man is the third host, if he eats raw or undercooked fish. E. P. L.

SEE ALSO: BACTERIA, BALANCE OF NATURE, BLIGHT, FILARIA, FUNGUS, HOOKWORM, LIVER FLUKE, MOLDS, PINWORM, PROTOZOA, TAPEWORM, TRICHINA, VIRUS

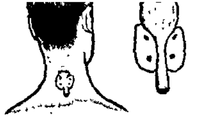
Parasympathetic see Autonomic nervous system, Nervous system

Parathyroid (par-uh-THY-royd) The parathyroid is a special gland in the body. There are actually four parathyroid glands. Two pairs of these tiny pea-shaped structures rest on the back of the THYROID gland. The parathyroid glands secrete a hormone called *parathormone*.

Parathormone controls the amount of calcium and phosphorus in the blood and the way in which these minerals are used by the body. Normally there is a balance in the body between the level of calcium and phosphorus. When there is too little parathyroid hormone, there is a rise in the level of phosphorus in the blood and a drop in the level of calcium. If blood calcium is markedly decreased, a condition called *tetany* occurs. In such cases, the muscles of the body become irritable and contract, producing spasms throughout the body. The muscles of the larynx may be involved and obstruct the passage of air from outside into the lungs. The muscles controlling breathing go into spasm. Death results in severe cases. Accidental removal of the parathyroid glands during surgery can produce the same effect.

Oversecretion of the parathyroids is called *hyperparathyroidism*. It may be caused by tumors of the glands or by other disturbances of calcium-phosphorus metabolism. The blood level of calcium rises and the level of phosphorus falls. In such a condition there is a loss of calcium from the bones. This calcium loss causes a weakening of the bone structure. Bone pain, fractures, bone deformities, kidney stones, and nephritis often result. G. A. D.

SEE ALSO: ENDOCRINE GLANDS



Parathyroid glands around the thyroid

Paré, Ambroïse (pah-RAY, ahm-BRWAHZ) (1510-1590) Paré was a French barber-surgeon who became the greatest surgeon of the Renaissance. He later became known as the "father of modern surgery."

A barber-surgeon was just what the name implies. He cut men's hair and shaved them, but he also drew blood and performed all kinds of surgery from treating cuts to amputating limbs. However, the barber-surgeons were despised by medical surgeons and barely tolerated by the people themselves. Paré's humble birth committed him to this position. He was unable to attend a university to study Greek and Latin, subjects absolutely necessary to the training of a physician of that period.

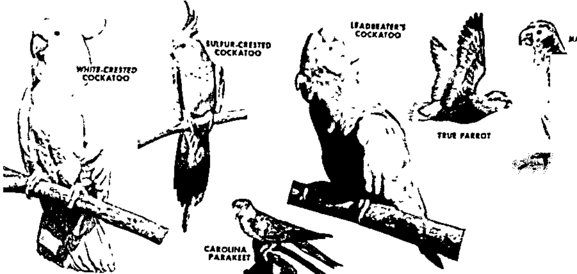
During Paré's lifetime France was at war against Italy, Germany, and England, and later against the French Huguenots at home. After a three-year appointment at the Paris Hospital, he joined the French army and saw military service for the next thirty years. He performed so many operations of every sort on so many men that he developed new techniques and methods of treating wounds. He invented artery forceps and other types of surgical instruments.

In 1554 Ambroïse Paré received the greatest honor of his life. He was made a member of the College of St. Come, the most important surgical society of France at the time. D. H. J.

Paregoric (par-uh-GORE-ick) Paregoric is the name for a preparation containing a small amount of OPIUM, ANISE oil, benzoic acid, honey, dilute alcohol, and camphor. It is used in the treatment of DIARRHEA and as a pain reliever.

SEE: NARCOTICS

Paris green see Arsenic



Australian News & Information Bureau

Chicago Natural History Museum

Parkinson's disease Parkinson's disease is a condition which affects the NERVOUS SYSTEM. The symptoms of the disease are stiffness of muscles, slowness of movement, and tremors of resting muscles. These rhythmic tremors occur as the limbs rest after excitement or exertion.

The disease is a progressive one. At the onset the tremors are mild, but as time goes on the tremors become more severe and obvious. Those suffering with Parkinson's disease experience increasing difficulty in writing, in dressing, in maintaining balance, in turning around, and in rising from a seated position. It is only in the later stages of the disease that the patient's speech shows obvious change

Parkinson's disease occurs most often among those between 50 and 60 years of age. Men are afflicted with the disease more frequently than women. It may be caused by poisoning, strokes, head injury or more commonly by ARTERIOSCLEROSIS, or hardening of the blood vessels of the brain. Drugs are often used in the treatment of the disease. They are useful in lessening the rigidity of muscles and controlling the tremors to some degree. In some cases surgery has been attempted but at the present time its effectiveness is uncertain. G. A. D.

Parrot Parrots and their relatives, the macaws, parakeets and lories, make up a large family. They are brightly colored birds ranging from warbler ‑ eagle size, with strong, hooked · and hawk-like heads. The upper jaw moves up so that the beak ca work like pliers, crushing the parrot' food.

The 316 species ot parrots live in th tropics all over the world. At one time par rots lived in colder regions and disappeare from North America only recently. The travel in pairs or gangs through the tops o tropical forests, shrieking to each other when food is found.

Parrots can be divided into two groups depending on whether their thick, fleshy tongues are fringed or blunt. The former eat nectars and fruit juices and the latter eat seeds and nuts. One branch of parrots, the lorikeets, crush blossoms and lick up the sticky nectar with their tongues.

Parrots use their feet as hands to eat. Two of the four toes are turned backward. They are either left or right-handed. They are good climbers, using their beaks to help.

Most species nest in holes in trees but a few build stick nests. The male helps the female incubate the eggs for three weeks and the young hatch out blind and naked. Most species feed their young on partly digested food.

Men have made pets of parrots since ancient times. They are the best talkers in the animal kingdom and are good at voice mimicry. As pets, they may live from 50 to 80 years. At one time when it was found they carried *psittacosis*, or parrot fever, their popularity declined but now an antibiotic is available which will cure birds of this disease. E. R. B.

SEE ALSO: ANIMAL DISEASES, MACAW, PARAKEET

Parrot fever see Animal diseases, Parrot

Parsley In modern cooking, parsley is mainly a flavoring and decorative herb. Sprigs of its leaves give a delicate taste and a lacy, green garnish to soups, salads, and meat or cheese dishes. This leafy sweet herb is grown in several varieties. Many have been grown since ancient times in Mediterranean countries.

Besides plain parsley, two other popular varieties are *paramount* and *moss curled. Hamburg* variety has an enlarged root looking like a parsnip but tasting like celery.

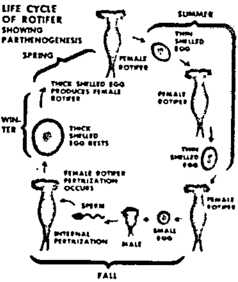
Agricultural department food bulletins state that parsley is a good source of vitamins A and C and a fair source of niacin. It is rich in iron, but one is not likely to eat large enough amounts to supply much of that element for the body. D. A. B.

Parsnip The parsnip is a root vegetable. It looks like a carrot but is yellow-white in color. It has a tangy sweet, celery-like flavor. It grows best only in cool temperate climates, and its flavor improves when it is left in the winter soil or stored in a cold place for awhile.

Parsnip seeds can be planted in rich soil, in the spring. They germinate slowly. The leaves have a dark-green, celery-like appearance. By fall, they may grow to be over one foot tall. Chemicals may be sprayed to ward off animal and plant pests.

Care should be taken not to confuse the parsnip plant or its roots with the poisonous weed, water hemlock (*Cicuta*), which has a similar appearance and odor. D. A. B.

SEE ALSO: LEAVES



A rotifer's life cycle illustrates parthenogenesis

Parthenogenesis (pahr-thuh-noh-JENN-uh-siss) Parthenogenesis is a type of reproduction in which a new organism develops from an egg which has not united with a sperm. In animals, it occurs naturally in *rotifers*, a type of worm, in BEES and ANTS, and in water fleas. Some algae and fungi also reproduce parthenogenetically. Eggs of many invertebrates and of frogs have been developed without fertilization through artificial stimulation of the eggs by pricking, shaking, and changing the kind of solution they are in. Occasionally parthenogenesis occurs naturally in all major groups of animals except the vertebrates and echinoderms and in all plants except mosses and liverworts.

Parthenogenesis is the sole means of reproduction only in a few aphids and parasitic insects. In other groups males are produced periodically, usually in the fall. These fertilize eggs which are capable of surviving the winter. These eggs in turn produce females which reproduce parthenogenetically as females until the next fall.

A slightly different parthenogenetic reproduction occurs in bees. The queen bee is the sole egg-producing female. It mates once with a drone and stores the sperm in its body. The fertilized eggs which it produced develop into queen bees or workers (infertile females). It also lays unfertilized eggs which have half the number of chromosomes of the female bees. These develop parthenogenetically into the male drones. J. K. L.
SEE ALSO: REPRODUCTION, ASEXUAL; REPRODUCTIVE SYSTEMS; ROTIFERA

Particle see Nuclear particles

Particle detector Charged atomic or NUCLEAR PARTICLES are detected when passed through a particle detector. The charged particles create an electrical disturbance which can be observed, as in the Wilson CLOUD CHAMBER, or recorded, as in the Geiger-Müller counter.
SEE: GEIGER COUNTER

Partridge see Fowl, Grouse, Quail

Parturition Parturition is the act of giving BIRTH to young. It begins with contractions of the uterus which force the infant out of the uterus and through the vagina, and it ends with the delivery of the placenta.
SEE: REPRODUCTION, SEXUAL

Pasqueflower see Wild flowers

Passion flower see Plants, tropical

Pasteur, Louis (1822-1895) Louis Pasteur was the French chemist who became known as the "father of bacteriology." He was the first scientist to discover how to prevent the spread of diseases caused by INFECTION. He proved that the microscopic organisms found in liquids after a chemical change (a process known as FERMENTATION) came from the air. He also discovered that they could be killed, thus preventing the

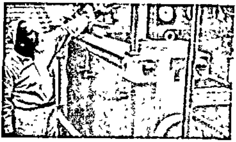
Louis Pasteur

spread of disease. The process discovered to kill these germs in mi and dry wines by heating the liquid a point just below the boiling poi and then cooling it rapidly is calle *pasteurization.*

Louis Pasteur was born at Dole, Franc He was the son of humble parents. H father was a tanner; his mother, a gardener' daughter. As a boy he was in no way un usual. His teacher described him as "a goo average pupil" and one who "never affirmed anything of which he was not absolutely sure." With money his father somehow had managed to save, Pasteur attended the Ecole Normale in Paris to study chemistry. Later he did advanced work in chemistry at the Sorbonne.

In 1849, Pasteur was invited to serve on the Faculty of Sciences as the professor of chemistry at Strasbourg, and it was there that he began his research on fermentation. There he first showed that certain organic chemicals made by plants exist in two light-polarizing varieties. The improvements he eventually brought about in winemaking are said to have saved France enough money to pay its indemnity to Prussia at the close of the Franco-Prussian War. In Strasbourg, also, Pasteur met Marie Laurent, the daughter of the Rector of the Academy. They were married in May, 1849, and for the rest of his life, she remained his partner, sharing his misfortunes as well as his successes.

In 1854, Pasteur became the Dean of the new Faculty of the Sciences at Lille. Although his administrative duties combined with his teaching responsibilities made a heavy load, he consented to make a thorough study of a disease threatening to destroy the silkworms in France. For five years he carried on intensive research, and eventually discovered the parasite causing the disease. This gift to France saved the entire silk industry of the country.



Courtesy Society For Visual Education, Inc

Milk is put into sterilized bottles (left) after being pasteurized by this machine

Pasteur's second great claim to fame (after pasteurization) is his work in medicine, especially his development of a vaccine against rabies. While experimenting with chicken cholera, he stumbled upon the principle of using killed or weakened viruses to make animals resistant to diseases. This principle is called *immunization*. He next applied the idea to anthrax, a disease that attacks cattle and sheep. Then he began looking for the germ that causes rabies. The disease, sometimes called *hydrophobia*, was known to be transmitted by the bites of animals that were sick with it. A dog that had rabies was called a "mad dog," and was terribly feared because the disease was usually fatal. Pasteur developed a vaccine against it, and his first human patient, nine-year-old Joseph Meister, recovered.

Even more dramatically, 16 out of 19 Russian peasants who had been bitten by a mad wolf were saved by Pasteur's injections, despite the fact that the treatment was not started until 19 days after they were bitten. They had had to come all the way from Russia. In recognition, the Czar donated 100,000 francs toward the building of the Pasteur Institute. This institution, built by contributions of people in every land, is a living monument to Pasteur. He served as its director from 1888 until he died in 1895. D. A. B.

SEE ALSO: MEDICINE, PASTEURIZATION

Pasteurization (pass-ter-ih-ZAY-shun) After milk leaves the farm and goes to the dairy, it goes through a process called pasteurization. This process destroys dangerous disease-causing microorganisms.

Pasteurized milk has been heated and held at a given temperature for a certain length of time. This can be accomplished in two ways. The milk may be heated to about 143 degrees Fahrenheit and held at that temperature for thirty minutes, or it may be heated to 160 degrees Fahrenheit and held for about sixteen seconds. The process destroys most microorganisms and spares the flavor of the milk which higher temperatures would affect. The same process is also applied to wines.

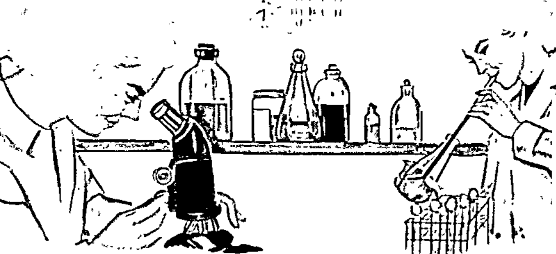
Microorganisms, too small to be seen without a microscope, are the cause of tuberculosis, typhoid fever, dysentery, undulant fever, diphtheria, scarlet fever, and septic sore throat. Pasteurization prevents the spread of disease through the milk supply.

Pasteurization does not kill all the microorganisms present in milk. Many bacteria still live, but these are not harmful to the body. Milk is tested from samples taken from each source. The city or county health department is responsible for this task, and milk is graded according to the bacteria *count and number of coloform organisms* in each milliliter.

Unpasteurized milk may still be sold in some communities, but it must be used more quickly than milk which is pasteurized. Almost all milk sold in stores is Grade A pasteurized. Lower grades of milk are used in making powdered milk or cheeses as the bacteria will be destroyed by cooking or chemical treatment. V. V. N.

SEE ALSO: BACTERIOLOGY; DAIRY PRODUCTS; PASTEUR, LOUIS

Patella see Skeleton



A pathology laboratory may make a variety of tests on samples of blood, urine, saliva and other bo[dy] fluids or tissues to aid the physician in making a diagnosis of a disease

Pathology (puh-THAHL-uh-jee) Pathology is the branch of medical science which considers the changes of function and the changes of structure brought about by disease.

General pathology is that division of pathology which studies those abnormal processes caused in different organs of the body by diseases. An example of such a change is that found in an inflammation showing redness, swelling, heat, and pain.

Humoral pathology, an older science introduced by HIPPOCRATES (460 B.C.-355 B.C.) attributed the cause of disease to an abnormal condition of the blood. *Cellular* pathology, which was formulated about 1840, considered the cell as the basis for all living phenomena. Today pathology recognizes both the humoral and cellular concepts.

Other subdivisions of pathology are *pathologic physiology*, which deals with disturbances of function in disease; *morphologic* pathology which deals with the study of structural changes in disease; and *special* pathology, covering special diseases.

The study of pathologic physiology received its first great impetus about 1830 to 1840 from Karl Rokitansky, professor of Pathological Anatomy in Vienna. Rokitansky had tremendous experience, having performed 30,000 autopsies during his lifetime. He emphasized, however, that medicine wished to understand the living, rather than dead, organs. Because of his background he was a genius at presenting a pathologic description of diseased parts, in presenting an understanding of the *pathogenesis* (development) of disease, and, then, in correlatin[g] anatomy with the symptoms of the diseas[e].

Rudolph Ludwig Virchow (1821-1902) was the father of cellular pathology. Becaus[e] the humoral theory had held sway for almos[t] 2000 years, introduction of cellular pathology was courageous as well as progressive. Virchow's thesis stated that the seat of disease should be sought in the cell. This concept not only replaced the older humora[l] theory, but it did not restrict study to gross material, and required a more thorough investigation of microscopic, cellular changes. Virchow taught in Berlin until 1849, but his political utterances demanding improved health conditions antagonized Bismarck, who was the outstanding Prussian politician of his day; and he was forced to leave.

By correlating studies of tissue and organs removed during surgical operations and studies of disease in the living body, the pathologists learn something of the life processes.

Fever, for instance, is a pathologic change caused, in most cases, by the presence of poisonous substances called *toxins* in the blood acting upon the heat centers within the brain. These substances may be bacterial poisons, metabolic products, end products of protein digestion, or ferments. Toxins are also produced by injury, by direct exposure to heat as in sunstroke, by starvation, or even by hysteria. Any infectious process within the body may produce fever.

The changes in body tissue brought about by the toxic substances just named result from increased oxidation and body waste. During a fevered condition the amount of nitrogen in the urine is in excess of the amount in food taken into the body. The

specific gravity of the blood is increased, and the alkalinity of the blood is reduced by various acids produced in tissue destruction. The hydrogen ion concentration of the blood is reduced. If the fever is excessive or protracted, the muscles, heart, liver and kidneys are the seat of fatty degeneration (seen with the microscope) and coagulation. Necrosis, or death of the tissue cells, occurs within these organs. By knowing of these changes brought about by varying disease phenomena, corrective steps can be taken to stop the process and restore health.

The trained pathologist must be not only a practical clinician; he must also have a basic knowledge of human and comparative anatomies, of histology, physiology, embryology, biochemistry, and bacteriology. The knowledge of his field thus serves the future of clinical medicine. H. K. S.

SEE ALSO: MEDICINE, PHYSIOLOGY

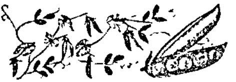
Pavlov, Ivan Petrovich (1849-1936) Ivan Pavlov was a Russian doctor (physiologist) who is now remembered for his work on conditioned reflexes in dogs. He discovered that if he always rang a bell each time he fed a dog, the dog would continue to react to the bell even when food was withheld. He was awarded the Nobel Prize for his work on digestion.

Born in Ryazan on September 14, 1849, Ivan Pavlov, the son of a priest, attended Ryazan Seminary for four years and then the University of St. Petersburg where he studied science and then medicine. After receiving his M.D. degree in 1883, he traveled to Germany to work under two leading physiologists. Two years later he returned to St. Petersburg where he began his experiments at the Military Medical Academy. Pavlov's work was in three basic areas: circulation of the blood, action of the digestive glands, and formation of conditioned reflexes. His research on techniques causing neuroses in dogs laid the foundation for scientific study of mental illness in humans.

Pavlov achieved world-wide fame as his writings were translated into German, French, and English. D. H. J.

SEE ALSO: PSYCHOLOGY

Pawpaw see Papaya



Garden pea plant and pod

Pea The garden pea is an annual, climbing herb. The green or yellow seeds formed in pods are used as a vegetable. *Pea* also refers to a large family of plants (*Leguminosae*) which includes locust trees, mesquite shrubs and peanut plants.

Garden peas have hollow stems, white flowers which are self pollinated and fruit classified as LEGUMES The roots develop nodules containing nitrogen-fixing bacteria Field peas are hardy plants used mainly for stockfeed. The pigeon or cajan pea is gaining popularity as food for poultry, humans and livestock.

The pea is the plant that MENDEL experimented with in doing his well-known work in breeding and genetics. H. J. C.

Peach The peach tree bears fruit that has one large seed. The tree grows until it is about twenty-five feet tall. The leaves are long and narrow. The flower, of a pinkish hue, is the state flower of Delaware.

The peach tree, a member of the rose family, is native to China and has been culti-

Peaches, ready for picking

U S Department of Agriculture photo

vated for over 4000 years. It produces best in regions where the winters are mild and the temperature rarely goes below ten degrees below zero. Many peach trees grow in the wild state.

Botanically the fruit is classified as a DRUPE. The outer fruit wall is fleshy with a stony endocarp surrounding the seed. The pit is grooved. Peaches produced are *free stone* or the *cling* variety. The *Elberta peach* is most widely grown. The tree starts to bear fruit after three or four years of growth. The flower and fruit appear on the new branches each year. A volatile and fixed oil are extracted from the seed. Brandy is made from the fruit.

Leaf curl, brown rot, scab, peach borer and oriental fruit moth are the most serious pests of this plant.

Nectarines are a variety of peach. The fruit is smaller, more solid and the exocarp is smooth. H. J. C.

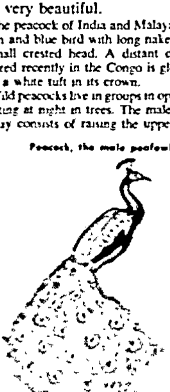
SEE ALSO: FRUIT

Peacock Peacock is the name for the male peafowl. The peafowl is related to other fowl, such as quails, pheasants, and chickens. Almost all zoos have peacocks, many wandering free, because they are easily domesticated and very beautiful.

The peacock of India and Malaya is a large green and blue bird with long naked legs and a small crested head. A distant cousin discovered recently in the Congo is glossy black with a white tuft in its crown.

Wild peacocks live in groups in open forests, roosting at night in trees. The male courtship display consists of raising the upper long tail

Peacock, the male peafowl



coverts into a fan which reaches the ground on both sides. The feather surfaces are covered with many thin layers of horn which r
and refract light, making the colors irides
Yellowish spots add to the beauty. Thes
coverts develop in the male's third year.
male has a harem of two to five smaller
duller females. The buff-colored eggs are
in a crude nest on the ground. E.

SEE ALSO: FOWL

Peafowl see Peacock

Peanuts see Legume, Nuts

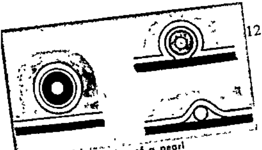
Pear leaves, fruit and flower

Pear The pear tree has been grown
over 4000 years. It is a member of
rose family. In the United States, m
pears are grown in the northweste
states. These trees cannot stand
tremes of temperature change as
ple trees can, therefore they are rat
limited to certain regions.

The leaves of the pear tree have serra
margins. The flower has five petals and f
carpels and is generally white. The flower
perfect, meaning that both male and fem
parts are present. The fruit is classified
accessory since much of the wall is the fles
receptacle. The grittiness of the fruit is caus
by the presence of minute stone cells
schlerenchyma tissue.

Propagation is done by seeds or graft
The dwarf pear is grafted onto a slow grow
rootstock such as quince. Besides using
fruit as food, man extracts oil from the seed
A drink called *perry* is made from the fr
juice H. J.

Pearl A pearl is a gem made by certa
animals that live within shells. Thes
animals are *mollusks*. A pearl
formed when a grain of sand or othe
small object gets between the hard ou
er shell and the inner coat, called th
mantle.


Formation of a pearl

The mollusk surrounds the irritation with *nacre*, a secretion from the mantle This is the same substance that lines the oyster's shell and is called *mother-of-pearl* Many thin layers of nacre give a pearl its luster The result is a sore spot for the oyster but a beautiful jewel for man.

The biggest pearl oysters are found in the South Seas The Persian Gulf yields a yellowish pearl. Some may be pink, bluish, gray, or black The coasts of Australia, Venezuela, Malaya, Mexico, and lower California are other important sources of pearls Many mollusks produce pearls, but only two types produce precious pearls These are the genera *Meleagrina* of the tropical seas and *Unio* of fresh water streams

The average pearl takes about seven years for its development Its value is determined by its size and luster The largest pearl found was about two inches in diameter *Cultured* pearls are real pearls but the original nucleus was inserted by man They are not as costly as true pearls

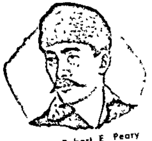
Unfortunately, pearls are perishable Sunlight and skin acids are injurious to them Pearls should be kept clean and wrapped in moist coverings when not in use With care, they last over a hundred years J A D

SEE ALSO: GEM, MOLLUSCA

Peary, Robert Edwin (1856-1920)

Robert Peary was the American explorer who discovered the North Pole. From soundings taken, he also discovered that the sea around the North Pole was not as shallow as was popularly believed up until that time.

Peary was born in Pennsylvania, but his family soon returned to Maine, where his ancestors had lived. He attended Bowdoin College where he took the civil engineering course. He worked first as a land surveyor in Maine and then as a draftsman for the U.S. Coast and Geodetic Survey. He passed the difficult examination for civil engineers in the U.S. Navy and took up his lifelong


Admiral Robert E Peary

career in engineering from which leaves of absence when he wer Arctic explorations He first w ship canals and dry docks Whe was being planned across Central Peary was sent to survey the po a route across Nicaragua He credited with being one of the neers to recommend that the ca through the Isthmus of Panama was ·

His first four Arctic journ Greenland His wife went w several of these expeditions a child, Marie, was born in further north than any but Es had ever been born before F the first man to cross Greenla explorer, Nansen beat him by gin, but he made many usef He established the fact tha an island, he found and brou enormous meteorites, and h with the Eskimos and learr methods and clothing

With the knowledge g Greenland explorations Pe on reaching the North Po to sail a ship as far nort along the Greenland coa with dogs and sledges T expeditions two ships an toes later, he achieved hi when he planted five f Pole were his Negro assis son, who accompanied his trips, and four Esk their achievement stoo captain of the ship *Ro* men who had been w break trail, build igloo plies so that Peary companions could not Pole, but also come ba

Another explorer, claimed to have reach after a Congressiona decided that Cook ha it at all

Sphagnum moss is the common moss of peat bogs

Peat During the early stages of the Earth's development, plants such as mosses and ferns grew thickly in many swamps then present. As the plants died, their remains sank to the bottom and new plants grew on top of them. Great masses of half-decayed brown, spongy material formed. This is peat. If there had been more pressure and heat from the great amounts of sand and clay that were gradually piled on the peat, the peat would have changed into coal.

The wet marshy ground where peat is found is called a *peat bog.* The water in a peat bog is acid and preserves plants that fall into it. Botanists are able to identify plants that grew in peat bogs centuries ago. The most common type found is the large sphagnum.

Most of the peat deposits were formed during the Carboniferous Age. Mosses, giant ferns and ancient conifer-like plants became bogged down in stagnant swamps. When these were covered with clay, they were more or less hardened into peat, lignite or harder COAL.

Peat has many uses. It is used as a FUEL even though it leaves ten times more ash than most other fuels. It holds water well and so is used for surgical dressings, soil conditioners and a propagating medium. H. J. C.

SEE ALSO: MOSS

Pecan see Hickory, Nuts

Peccary (PEK-ar-e) The peccary is a hoofed, tailless, piglike animal with tusks that turn downward. It is a vicious fighter, and usually travels in herds. The two species, the collared peccary and the white-lipped peccary, are found from Texas to Paraguay.

Peccary, or javelina

Pectin (PEK-tin) Pectin is a carl hydrate found in ripe fruits and soı vegetables. It dissolves in boiling waı and forms a jelly when cooled. Coı mercial pectin can be bought in stoı and used to make jellies. It also h various uses in medicines.

Pedigree A pedigree is a record of family. It may be of a family of plant animals, or humans. A person's ped gree is called a *family tree.* It tells th name of parents, grandparents, an ancestors back through the centurie and gives information of cities an counties where they were known t have lived. Anyone can make a simpl family tree.

In animals and plants, pedigrees are o great value in breeding certain desirabl characteristics into the offspring. These records of ancestors help to improve varieties of plants and breeds of animals because they tell breeders the kind of offsprings the male and female will have. Two fast horses may produce a winning race horse. A male and female Airedale dog with proper proportions and markings may produce a champion puppy. More perfect and valuable fruits, vegetables, trees, and flowers may be developed when records are kept of the original plants. Pedigrees are a record for controlled breeding, an important science based on Gregor Mendel's laws of heredity. J. K. K.

SEE ALSO: BREEDING; HYBRIDIZATION; MENDEL, GREGOR

The peewee resembles other flycatchers, such as the yellow-bellied

Peewee The peewee is a member of the flycatcher family, often confused with the phoebe. It is hard to see and can be most easily distinguished by the sad way in which it says its name.

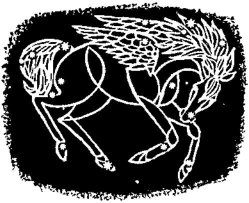
The adult is from six to six and one-half inches long, dark olive-gray above with a grayish-white breast. The wings are marked with whitish bars. It prefers to live in dry woods, often nesting in orchards. When it is feeding, it perches in the tops of trees and dives for flying insects.

The peewee breeds in eastern North America and winters in South America. The nest is broad and flat and beautifully made. It is covered so that it seems to grow out of a branch. E. R. B.

SEE ALSO: FLYCATCHER

Pegasus (PEGG-uh-suss) Pegasus is a group of stars that seemed to ancient people to outline the shape of a horse. This CONSTELLATION covers a large area of the sky. It can be found by locating the *Square of Pegasus.* Four bright stars mark the corners of this large square. The square represents the body of the horse. A line of stars ending in a triangle composes his neck and head. The horse is usually upside down. The stars that represent its forefeet usually point upward in the sky. Pegasus does not have any hind legs marked by stars.

Pegasus can be found most easily in autumn and winter. It is near the royal family of constellations—Cassiopeia, Cepheus, Andromeda, and Perseus. In fact, one of the stars of the square is part of the constellation of Andromeda.



Pegasus

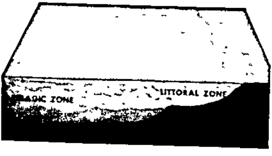
According to legend, Pegasus was the winged horse which sprang from the head of Medusa when Perseus killed Medusa. Either Minerva or Neptune tamed Pegasus and gave him to Bellerophon. Pegasus carried his master to Lycia, where Bellerophon slew Chimera, a monster Jupiter was displeased and sent a gadfly to sting Pegasus. The horse threw Bellerophon and flew up into the sky C. L. K.

Peking man see Evolution of man

Pelagic (puh-LAJ-ick) Pelagic is a term which is used to describe the part of the ocean away from the shore. This is the open sea which lies above the *abyss* or *depths.* The pelagic zone usually refers only to the part of the ocean as far down as sunlight penetrates.

SEE: CURRENTS, OCEAN, GRAND BANKS; MARINE BIOLOGY; OCEAN, PLANKTON; SARGASSUM

The major life zones of the ocean (not drawn to scale)



White pelicans

Pelican The pelican is a large fish-eating bird. It looks strange because of its short legs, crested head and hooked, pouched bill. It uses its pouch to help it catch food. All four toes of a pelican are webbed.

Pelicans live in groups in warm areas all over the world. Some kinds hunt together and are often seen flying in formation, gliding or beating their wings in unison. The white pelicans inhabit fresh-water inland lakes. The brown pelican hunts in salt water from the southern coast of the United States to southern South America.

Pelicans breed on islands in huge communities. They make nests in trees or on the ground near water. The nests are of sticks or pebbles and sand. From two to four eggs are laid and incubated by both parents, who are easily frightened away from the young. The babies take food from deep in the parent's gullet E. R. B.

Pellagra see Vitamin deficiency

Peltier, Jean Charles Athanase (1785-1845) Peltier was a French physicist now remembered as the man who completed a discovery made by T. J. SEEBECK. This discovery, made in 1834, revealed that an electric current produces either heating or cooling at the junction place of two different metals. The direction in which the current is traveling determines whether cooling or heating is produced.

In 1961, production of small-sized electric refrigerators using the cooling effect discovered by Peltier was announced. A clockmaker by trade, Peltier was born at Ham, France, on February 25, 1785. He died in Paris on October 27, 1845. D. H. J.

SEE ALSO: ELECTRICITY, REFRIGERATION

Pelvis The pelvis is the bony ring formed by the two hip bones and the *sacrum* and *coccyx* of the vertebral column. It is also the abdominal cavity which is enclosed by these bones.

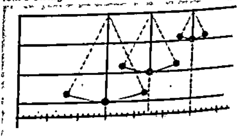
SEE: SKELETON

Pendulum (PEN-juh-luhm) A pendulum can be made by tying a weight, such as a stone, to a string. If the string is held and the weighted end is pushed, the string and weight will swing back and forth. A pendulum is used in certain clocks, in earthquake detectors, and in determining geological mineral deposits.

A simple pendulum has a weight, or *bob*, suspended from a fixed point by a light weight line. The bob swings back and forth in a path called the *arc*. The time it takes for a pendulum bob to swing from one end of the arc to the other and back again is called the *period of the pendulum*. If the length of the line remains the same, the period of the pendulum is affected only by changes in gravity—not by the width of arc.

Certain basic laws apply to a pendulum's period. A pendulum's period is not affected by the weight of the bob unless extreme air resistance exists. A pendulum's period increases as the length of line increases. The pendulum's period is directly proportional to the square root of the length of the pendulum's line. It is inversely proportional to the square root of the ACCELERATION due to gravity (g). In other words, short pendulums have short periods and swing rapidly. Pendulums with long lines have long periods

The changing length of the pendulum's string produces the different periods on the pendulum's swing



and swing slowly. In a pendulum clock, if the clock runs too rapidly, one lengthens or lowers the pendulum bob. If the clock runs too slowly, one shortens or raises the pendulum bob.

The *Foucault* pendulum, developed in 1851 by Jean Foucault, uses a large iron ball as the bob, connected to a 200-foot line. The arc of a Foucault pendulum seems to rotate very slowly as the ball swings back and forth. Actually it is not that the arc is rotating, but rather the earth is rotating under the arc of the pendulum. If one were able to look at the pendulum from a fixed point in space far away from the earth, one would see that the direction of the arc remains fixed in space but the earth makes one rotation under the arc each 24 hours. If a circle below a Foucault pendulum is marked in hours and minutes, the pendulum will give the time of the day. P. F. D.

SEE ALSO: CLOCKS, GALILEO, GRAVITY

Penguins are adapted to live in the icy Antarctic

Penguin The penguin is a large bird, often as much as four feet tall. It cannot fly but is well adapted for swimming. It can also stand erect and walk well.

The short tail, webbed feet and scale-like feathers help to make the penguin a fast swimmer. It propels itself with its wings both underwater and on the surface, using its legs as a rudder. Even its eyes are adapted for underwater vision. It feeds on fish and mollusks.

Penguins range in color from black and white to bluish gray and some kinds have bright orange or yellow markings. It molts all at once and the feathers grow back in about 14 days.

All but one of the 15 species of penguin live in the cold seas of the Southern Hemisphere. They are found on islands off Africa, Australia, New Zealand, in the Arctic Ocean, and on Antarctica. One colony of about 250 birds lives on the Galapagos Islands, near the equator.

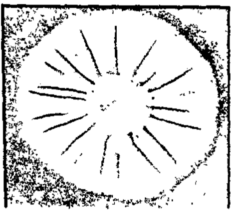
The penguin courtship begins early in the winter. Birds tend to keep the same mates year after year and return to the same nesting grounds. Some species nest in holes and under rocks and others on the surface. Often the males are left to incubate the eggs, not eating for weeks as they do. Since penguins live closely together in colonies, the adults often share the care and feeding of the young. The adults of some species swim out for food, and, as they return, feed the first and hungriest babies they find. In other species, the adults carefully find their own young. The fledglings reach down their parents' throats for partly digested food. In an Emperor penguin colony, it is not unusual to see a huge nursery of young birds guarded by one adult male. The young require several months to grow to full adult size. E. R. B.

Penicillin Penicillin was the first ANTIBIOTIC to be used successfully in the treatment of bacterial infections. Antibiotics are substances which are formed by living organisms. They are produced by MOLDS, soil organisms, and BACTERIA. Antibiotics interfere seriously with the organisms which produce disease. Penicillin has been used to treat many diseases that once were a great threat to life.

In 1928, SIR ALEXANDER FLEMING made a very great discovery. He found that a simple mold could destroy disease-producing bacteria. He noticed that a large colony

Laboratory-grown penicillium mold

Abbott Laboratories



of *staphylococcus* bacteria became transparent and hence dead, when they grew near a contaminating mold. This observation was the key to the discovery.

Fleming cultivated the mold in liquid broth, and noticed that during growth a substance was formed which inhibited the growth of some organisms. He called this penicillin, for the mold was *Penicillium notatum*.

Fleming then showed by experimentation that the extract containing penicillin was not poisonous to animals.

Since penicillin is a product of a mold, other species of molds were investigated for the presence of substances with similar properties. Thus a large number of antibiotic agents were discovered.

At present, several different forms of penicillin are known, and have been synthesized in the laboratory. J. R. S.

SEE ALSO: BACTERIOLOGY

Peninsula (puh-NINN-suh-luh) A peninsula is almost an island. It juts out from a larger land mass. The Malay Peninsula in southeast Asia is typical with its narrow land connection. Many peninsulas have very broad bases where they connect with the continent. Some geographers think the continent of Europe is like a huge peninsula of Asia.

Penis see Reproductive systems

Pennsylvanian see Geologic time table, Paleozoic Era

Penumbra see Eclipse

Peony (PEE-uh-nee) The peony is one of the showiest of modern garden flowers. The kind most popular is a hybrid of the *common peony* of southern Europe and the *Chinese peony*.

Double peony

Peonies belong to the *crowfoot*, or *buttercup*, family. There are over 300 varieties of the *bush peony*. It is a herbaceous PERENNIAL that reaches a height of about three feet. The flowers usually appear during June. They have single or double blooms ranging in color from white to red to purple. The petals are waxy. The large leaves possess deep grooves or divisions. The roots are fleshy and store food material for new growth each year. The stem has a red to green color. When peony bushes are separated and transplanted to a new location, flowers will not appear for a year or two while the plant rests.

Some peonies have woody stems and are called *tree peonies*. They grow about five feet tall with many branches and a great number of blossoms. The woody tree peonies are native to Pacific coastal areas of Asia and North America. H. J. C.

SEE ALSO: HYBRIDIZATION

Peperomia (peh-puh-ROME-yuh) Peperomia is a tropical plant raised for its attractive leaves. The leaves are a bright, shiny green with interesting markings and colors. Some leaves have brown, purple, or dark red markings, and others have light colored stripes between the veins.

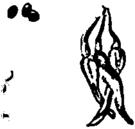
Peperomia comes from the moist forests of Brazil. It is a member of the PEPPER family. *Peperomia* is a Greek word meaning "pepper-like." It is an annual or perennial herb, depending on the variety.

Peperomia is a small-growing plant used in greenhouses, as a pot plant, or in hanging baskets. It should be shaded in summer, and requires lots of moisture and regular applications of liquid fertilizer.

The plants of this group are succulent with thick, fleshy, slightly oval leaves, three to six inches long. Its tiny flowers are crowded on a dense, slender, usually curving spike. M. R. L.

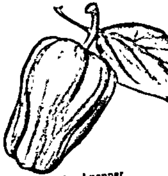
SEE ALSO: PLANTS, SUCCULENT

Peperomia



Pepper, the spice

Red, or chili, pepper



Green and red pepper

per Pepper is the name for several nts and products. The best known black pepper, a spice for flavoring od. It comes from a tropical vine ative to the East Indies, Thailand nd India. Twice a year the vine bears ruit in the form of green berries, which turn red. They are picked, dried in the sun and turn black. Then they are ground into fine, black pepper powder. The whole berries are called *peppercorns*. To get the best flavor, the peppercorns should be ground in a pepper mill at the time they are to be used.

White pepper is ground from the same ripe berries, after the dark outer rind has been removed.

Red pepper, not related to either black or white, is the dried, crushed pods of a large variety of hot chilies.

Green and *red* peppers found in vegetable markets are from entirely different plants, and their history has always been confused with the common table spice. They are called *sweet* or *bell peppers* and are berry-like fruits, related to the tomato and used fresh or cooked in salads, soups, and stews. The red bell pepper is simply the ripened green bell pepper. They were first found in the West Indies by a botanist of the Columbus expedition, who took samples back to Europe with him. J. K. K.

SEE ALSO: CAYENNE, PAPRIKA, PIMENTO

Peppermint plant

Peppermint A favorite member of MINT family, peppermint is an HI used for medicines, perfumes, so and for flavoring foods and ca

There are two common varieties of permint, black and white. The black dark green leaves, square stems, and p blossoms tinged with red at the tips o spikes. The white is a similar plan shorter and with lighter green leaves. T taken from the leaves of the white p mint is the best quality. J

Pepsin see Enzymes

Peptic ulcer see Ulcer

Perception see Eye

Perch Fish of the perch family fresh water—ponds, lakes and —of North America, Europe a They eat eggs, larvae, inse other fish. Perch are good to

In the spring, perch lay their egg string which sticks to shallow-wate single perch can produce an amaz of eggs.

The *yellow perch* is more bron than yellow. It has five to nin down its sides, a white belly, an lower fins. The *wall-eyed pike*, o sometimes grows to three times t average foot-long yellow perch. I from olive green to bluish-gray. *perch* is quite like the yellow per

SEE ALSO: FISH

Yellow perch

Chicago

Some perfume flowers—(from left) lavende[illegible] jasmine violets

Percussion (per-KUHSH-uhn) Percussion is the act of striking an object with a sharp, quick blow. The blow may be delivered by the hand or some instrument especially designed for the purpose of striking the object.

More commonly, percussion is related to the production of musical tones or rhythms. Many musical instruments employ the principles of percussion. The *drum* is considered a percussion instrument and is used for keeping the tempo or "beat" of the music. *Cymbals, tambourines,* and *castanets* are other examples of the same type of percussion instrument. The *piano* and *xylophone* are percussion instruments also, but they are capable of producing melodies as well as keeping the tempo.

Along more purely scientific lines, percussion is used to describe a point on an object such as a PENDULUM. When a blow is delivered to exactly that point, it will cause rotation only around the place of suspension. This point is known as the *center of percussion*. An example of this effect is shown by a baseball and a bat. If the batter hits the ball directly on the center of percussion, there will be no shock transmitted to the batter's hands as would be the case if the ball were hit any other place on the bat.

A. E. L.

SEE ALSO: MUSICAL INSTRUMENTS

Perennial (puh-RENN-ee-uhl) A perennial is a plant that lives longer than two years. A BIENNIAL lives two years. An ANNUAL lives one growing season.

Woody perennials include trees and shrubs. They have stems that live for many years. Each year, a new season's growth is added and the stem increases in diameter. Most woody perennials lose only their leaves after the growing season, and *evergreens* retain even their leaves or needles, sometimes for three years. *Herbaceous perennials* have stems that die down to the ground after the growing season. Plants such as RHUBARB, LILY, ASPARAGUS, and many GRASSES live through the w[illegible] use stored food from underground [illegible] tubers, rootstocks, and bulbs, [illegible] shoots that grow the follow-

M. R. L.

ANGIOSPERMS, ANNUAL RING, SEX

Perfume (PURR-fyoom) Perfume is a substance with a pleasing odor. It is made by blending oils, alcohol, and other materials.

Perfume has been in use since ancient times. In ancient Egypt, it was considered a symbol of immortality and was often placed in the tombs of the Pharaohs. The Bible frequently refers to the use of perfume. Perfume has grown in popularity through the ages, and is a favorite with women who like its good scent on their skin and clothing. It is used in soaps, shaving lotions, shampoos, cosmetics, and hundreds of other products.

The finest perfumes are expensive because of the high cost of the essential oils and fixatives used in their preparation. They are made in nearly all countries, but France is considered the leader of the perfume industry. Fragrant flowers such as lavender, carnations, jasmine, orange blossoms, and violets are raised in France and made into famous French perfumes. The finest rose perfume is made in Bulgaria. Most of the spice scents come from tropical sections.

Gland cells in the nectaries of flowers produce fragrant oils. These oils, or *attars*, are the essential oils that are blended with other ingredients to make perfumes. The essential oils are removed from flowers either by steam DISTILLATION; by allowing lard to absorb the oil; or by dissolving the flower oils with petroleum ether. It takes many thousands of pounds of flowers to produce an ounce of essential oil. This is one reason for the high cost of perfumes.

Fixatives are used in perfumes to make the scent last and to blend the many separate odors into one fine scent. Animal products such as ambergris, civet, and musk are fixatives. They must be properly treated, aged, and blended before use. Natural fixatives are very expensive and add greatly to the cost of perfume. Synthetic musk has been successfully made and used.

M. R. L.

Pericardium The pericardium is the closed membranous sac which envelops the HEART of vertebrates and some other animals. It holds the clear, serous liquid with which the heart is bathed. It consists of an outer and inner coat.

Perigee Either a natural SATELLITE (the moon) or a man-launched satellite (*Echo I*) moves in a curved path about the earth. Such a satellite's ORBIT is never a perfectly circular one, nor is the earth ever exactly at the orbital center. Therefore, at some time during each revolution, the satellite will reach a point when it is *nearest* to the earth. This near point is called the *perigee*.

SEE: APOGEE, ORBITAL SYSTEMS

Period see Geologic time table

Periodic table see Elements, Mendeleev's Periodic Table

Peripatus (puhr-RIP-uh-tuss) These shy little animals look like a caterpillar because they have short, stubby legs and a wrinkled body. But they are not insects. They have a long, soft, body and are often called "walking worms". But they are not worms.

These animals are not easy to find. They live in warm countries, like Africa and South America. Although all of them live on land, they must live in a damp place. They find shelter under stones, logs and tree roots in wet, tropical forests and come out only at night or during a rain.

Peripatus resembles a worm with legs

The peripatus seems to feed only upon dead animals. It is able to catch insects, termites and worms in a very interesting way. From two large salivary glands on its head, it spits out a sticky secretion like rubber cement. As this secretion dries, it entangles the prey.

Scientists often place the peripatus in a separate phylum with the name *Onychophora*, meaning "claw bearer." Although there are only about eighty different species, these animals were the first to have a true leg. From 14 to 40 pairs of fleshy legs turn downward and lift the animal off the ground. The peripatus provides a missing link between the segmented worms (annelids) and the jointed-legged arthropods.

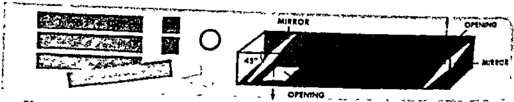
Like the annelids, they have a segmented head, fleshy, unjointed legs, and a similar excretory system. Like the arthropods, they have feet with curved claws, and a well-developed head which bears two long antennae. Like the insects, they breathe by means of tracheal tubes.

The male peripatus has three or four fewer legs than does the female. Most females retain the embryos inside their bodies until they are ready to be born. Since pregnancy for the peripatus lasts for over a year, the female may carry two litters of young in its body at the same time. At birth, the peripatus is about one-half inch long. However, it grows to a length of about five inches. F. P. L.

SEE ALSO: ANIMALS, CLASSIFICATION OF; ANNELIDA; ARTHROPODA; EVOLUTION

THINGS TO DO

MAKING A PERISCOPE



If you are too short to see over people's heads in a crowd then make this instrument. It will also enable you to peek around corners without your being noticed.

1 Cut four strips of balsa wood measuring three inches by one foot. These will form the sides of the tube. Cut two more pieces measuring three by three inches for the ends.

2 Cut out a two-inch square near the end of two side strips. Tape pocket mirrors at a 45 degree angle to the two sides with holes. Follow the illustration carefully. Tape the remaining sides, the top and bottom pieces to form a completely closed box.

3 It is now ready for use. Hold the tube upright and look through the bottom opening. Since light travels in straight lines the mirrors will reflect the object down to your eyes.

Periscope (PAIR-uh-skope) A periscope is an OPTICAL INSTRUMENT which enables a person to obtain a view otherwise impossible to see. Periscopes allow a SUBMARINE crew to survey objects on the surface of the water. A simple periscope can be made by mounting two mirrors on an angle within a tube or a narrow box. A person can look around a corner or over a fence with this homemade periscope.

A submarine periscope consists of a long, stainless steel or bronze tube. The optical lenses and prisms are sealed at the top by a glass window so they are watertight. When the periscope is raised above the surface of the water, light enters through the window. The light, striking a right-angle prism at the top, is totally reflected downward through several lenses to a second prism or a mirror. At this level the light is again totally reflected to the eyepiece, and thus to the observer.

Periscopes are also used for other military purposes. Warships and gun turrets carry accurate range finding periscopes designed to protect the operator from enemy fire. Tanks use periscopes, as do [illegible] [illegible] as a [illegible].

Periscopes are employed to observe radioactive materials. This is one way scientists can see over or through protective walls. Scientists can examine the inside of the stomach with a periscope-type instrument called the *gastroscope*. P. F. D.

SEE ALSO: LENS, MAN-MADE; PRISM; TELESCOPE

Peristalsis (per-uh-STAL-siss) Peristalsis is a type of movement, occurring in the hollow organs of animals, which causes the contents of the organ to be pushed out. Peristalsis occurs when the *circular* and *longitudinal muscle fibers* of the organ contract in rhythm. It occurs in circulatory, reproductive, and excretory systems but is most apparent in the digestive tract, where food is churned, mixed, and moved by peristalsis.

Circular fiber contraction makes the organ narrower and longer, while longitudinal fiber contraction makes it wider and shorter. The contractions begin at the top and run consecutively down the organ. If peristalsis is reversed in the upper digestive tract, vomiting occurs. J. K. L.

SEE ALSO: DIGESTIVE SYSTEM

Peritoneum see Abdomen, Peritonitis

Peritonitis (per-uh-tuh-NYE-tiss) Peritonitis is a very serious disease. It is an inflammation of the *peritoneum*. The peritoneum is the largest *serous* membrane of the body, and lines the abdominal cavity. It has two layers, an inner surface layer that is smooth and moist, and a rough outer layer which is attached to the inner layer. If this membrane becomes infected, peritonitis results.

Peritonitis may be caused by bruises or wounds, or by damage to the membrane by such diseases as TYPHOID FEVER, a chronic ULCER in the stomach, dysentery, appendicitis, cysts, tubercular or cancerous growths. It is either acute or chronic.

Acute peritonitis is not easily diagnosed because the patient may have INFECTION for a long period before it becomes acute and definite symptoms are produced. At first, pain is generally felt in one small local area. Later, the pain spreads and becomes worse, especially when the body is moved. Shivering and an enlarged, sore and tender abdomen are symptoms. Finally, profuse perspiration and chills indicate serious trouble.

Chronic peritonitis is sometimes the result of a case of acute peritonitis, and may take a very long time to cure. It is more often caused by deposits of tubercular or cancerous materials, or by ulcerations of the stomach. Symptoms are dull pain that increases with movement, poor appetite, a wasted appearance, and dry skin. M. R. L.

Periwinkle (animal) The periwinkle is a little SNAIL with a thick spiral shell. The shell is yellow, black, brown, or red with dark bands.

Periwinkles can be eaten and are used as fish bait. They are common in European waters and are now found on the Atlantic coast.

The periwinkle's head sticks out of the shell and its eyes are at the end of tentacles. When the animal moves, it swings from side to side on a foot that is divided lengthwise.

J W Thompson

The periwinkle is smaller than a man's thumb

The snail's tongue is twice as long as its body. The periwinkle clings to rocks where it lays its eggs and eats plants. P. G. B.

Periwinkle (plant) see Vinca

Permeability (per-mee-uh-BILL-uh-tee) Permeability is a measure of how easily fluids can penetrate and flow through a solid. Solids are permeable because they have networks of pore spaces through which fluids can flow.

Permeability is an important property of building materials and textiles. The permeability of sedimentary rocks like sandstone and limestone, through which flow water and oil into wells, has been the most carefully studied.

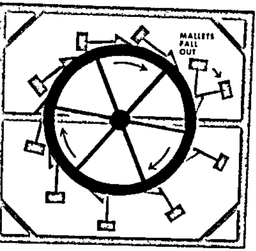
Magnetic permeability is a property of a substance which tells how much it becomes magnetized when placed in a magnetic field. The higher the magnetic permeability of a substance, the more highly magnetized it becomes when placed in a magnetic field.

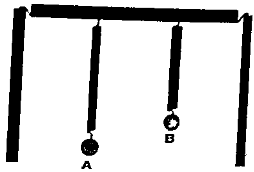
Permeability is also a property of semipermeable membranes. In this case, permeability is a measure of how rapidly a substance on one side of the membrane can diffuse through the membrane to the other side. The membranes around plant and animal cells are *selectively permeable*. These membranes will allow certain ions to pass through but will not permit other ions to pass. E. R. B.

SEE ALSO: MAGNETS, OSMOSIS

Peroxide see Oxygen

Perpendicular Perpendicular means exactly upright or at right angles to a line. A line perpendicular to another line or plane forms a 90 degree angle with that line or plane.





(Above) Spring-type perpetual motion machine. (Left) In the 1200's, a Frenchman planned a machine which used gravity to turn it forever. Mallets fall away from the rim on one side pulling it out of balance and making it turn. It will not start itself, and the energy used to start it turning is used up by friction

Perpetual motion machine Perpetual motion is an idea which people from ancient times tried to build into some kind of machine. The idea was that a properly built machine would run forever without having any constant supply of energy from outside itself. Thus, it would run itself while producing its own power to continue running.

The scientific view today is that a real perpetual motion machine is a practical impossibility. The reasoning is as follows.

Any machine starts to operate when supplied with some definite amount of energy of the proper type (for which the machine was designed) and of the proper "energy order-level." High-level energy forms include those mechanical motions of an engine drive-rod or a steady current of electricity or of a hot object sending its heat (molecular motion) into a colder object. The colder object has the lowest order of energy of the whole series named.

As the machine starts up, the moving parts rub together and wear away. Thus they waste some of the original high-level motion and spread it about as worn machine fragments and low-level heat. In short, friction and heat loss are the two ever-present conquerors of perfect use of energy and thus of perpetual motion. The *second law of thermodynamics*, states that the heat in a ·' ! cannot be completely changed into mechanical energy—except if the machine could work at absolute zero (−460° F., −273.1° C.). ABSOLUTE ZERO temperature has never been reached.

The planets and natural satellites, such as the moon, do seem to travel about their central bodies perpetually, for they move in the near-vacuum of space and undergo little or no friction. The main friction-like forces on satellites are those made by space debris—meteors, or comets. Such debris—or large-sized collisions—might sometime end the perpetual motion of even these bodies.

One of the many proposed perpetual motion machines is that sketched above, right. It has three springs, one of which is supported by two upright rods. The other two have metal spheres at their lower ends.

The system is started by introducing energy into sphere A; that is, it is set to vibrating up and down. Eventually sphere B will vibrate and A will come to rest.

This process will repeat itself for quite some time. Then why will it fail in perpetual motion? There will always be some air friction; and even in a vacuum, there will also be the internal friction and heat loss of the molecules in the springs themselves. Without adding more outside energy then, this machine will finally run down.

The perpetual motion idea has been valuable since it has led men to build better machines—with better lubrication and finer parts, such as ball bearings. A. E. L.

Petrel

Petrel The petrel is a small seabird with long wings. It has the ability to fly for long periods of time and to sleep on water. Some return to land only to breed.

SEE: FALCON

Petrifaction (pet-ruh-FACK-shun) Petrifaction is the process in which materials such as wood become rock formations. This happens through a replacement of the original substance by minerals of various types. The best known examples are the Petrified Forests found in Arizona. These are classified as a kind of FOSSIL.

The word *petrifaction* explains what has occurred. *Petri-* means "rock," and *-faction* refers to "make." Thus petrified wood becomes "rock made from wood."

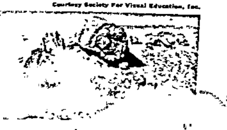
Wood started petrifying millions of years ago when conifer trees lay decaying. Minerals including silica, pyrites, and dolomites in water solution penetrated the cells of the wood. The minerals, separating from the water, left all spaces filled with solid rock. These logs have thus been preserved in forms very much as they originally appeared. Branches and leaves have, of course, disappeared.

These petrified logs are three and four feet in diameter and some are over 100 feet in length. Their colors run through grays and browns with variations of shading as well as patches and streaks brought about by various combinations of minerals. D. J. I.

SEE ALSO: PALEONTOLOGY

Petrified Forest, in Arizona

Courtesy Society For Visual Education, Inc.



Petroleum (puh-TROW-lee-uhm) The formation of petroleum, or crude mineral oil, took place long ago when great seas covered most present-day land masses. As the seas came and went with the shifting of the earth's surface, organic materials from plants and animals were buried with sediments from oceans and rivers. These sediments were subjected to great pressure and bacterial action, thus slowly becoming petroleum.

As a result of folding of the earth's crust, pockets or reservoirs of gas, oil, and salt water formed in the rock layers—valuable resources awaiting man's discovery. The earliest known use of petroleum was during Biblical times when surface-seeping pitch was used to seal the seams of ships. Often men dug for salt water to get edible salt, and found black oil instead. Knowing no use for the oil, the wells were abandoned.

In the mid-nineteenth century, a saltmaker, Samuel Kier of Pittsburgh, bottled and sold petroleum as medicine. Samples of this "rock oil" reached Professor Benjamin Silliman of Yale University in 1855. He analyzed it and separated out light-weight fractions that burned in lamps better than the commonly used spermwhale oil.

The chief oil-producing countries are: The United States, Venezuela, Russia, Saudi Arabia, Kuwait, Iraq, Indonesia, and Iran.

The most important early product of oil was *kerosene*, and the lighter *gasoline* which would explode in kerosene lamps was thrown away. Today, the chief products are: NATURAL GAS, gasoline, kerosene, lubricating oil, FUEL oils, asphalts, and oil coke.

Much of the oil recovered from oil deposits today is found off shore along the sea coasts where special drilling rigs are set up.

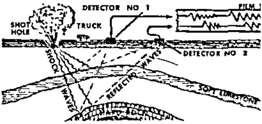
Crude oil recovered from the ground is separated in the gas-oil separator. Then it is sent through a network of pipelines throughout the country to be refined.

With the tremendous demand for different oil products there are over 4000 oil fields producing over 2½ billion barrels annually. There are over 30 billion barrels of proved United States petroleum reserves. E. Y. K.

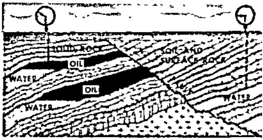
SEE ALSO: OIL WELL, ORGANIC COMPOUNDS

American Oil Co.

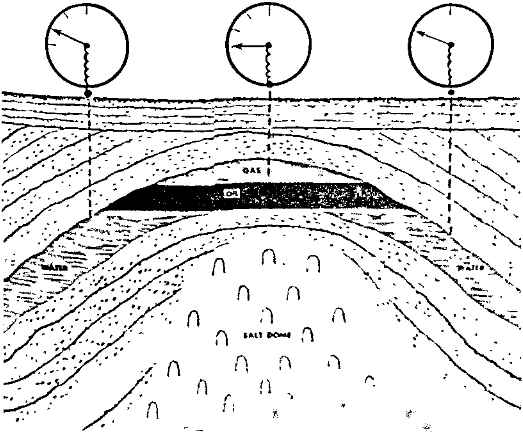
In giant oil fractionating towers, crude oil is made into high-octane gasoline



Locating petroleum with a seismograph



The gravimeter can help in locating petroleum deposits. When used over a fault, as shown above, gravity registers stronger on the raised side of the fault as dense rock is closest there. Below is shown the gravimeter registering less gravitational pull as it is used over a salt dome, because salt is lighter than surrounding rock



Petroleum jelly Petroleum jelly, or *petrolatum,* is a semi-solid substance obtained by refining the greases which result from the distillation of PETROLEUM. It is used as a protective dressing, a base for ointments, a lubricant for metals, and a leather-softener.

Petrology see Rocks

Helen J. Challand

Pink petunias

Petunia The petunia is one of the favorite flowers of home gardeners. The velvety, funnel-shaped blossom of the petunia may be white, pink, reddish, violet, purple, or sometimes striped. Some hybrids, or mixed varieties, have ruffled edges. The petunia is a member of the NIGHTSHADE family.

The petunia is a hardy annual and a satisfactory flower for beginners to grow. Seeds should be sown early indoors or in a cold frame. Some gardeners say the smallest and slowest-growing seedlings often produce the best colors. The many leaves and the stems of the plant are covered with hair-like structures.

Petunias like a rich soil and plenty of sunshine. They are not only a popular flower for the backyard garden, but they are widely used for window boxes, porch boxes, and hanging baskets. J. K. K.

Pewter is an ALLOY of tin and
d in the proportion of four to six
tin to one part of lead. Some-
antimony, or zinc are
d of lead.

Caventou and Pelletier o
quinine from cinchona bark

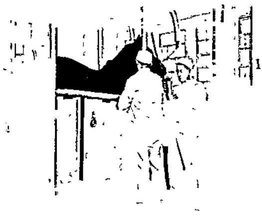
Pharmacology (fah
uh-jee) Pharmacology
that deals with the acti
and other chemicals c
man. It is different fr
which is the preparing
medicines of known act

Pharmacology is a yo
recently has become
only to doctors and dru
to research biologists st
produced chemicals.

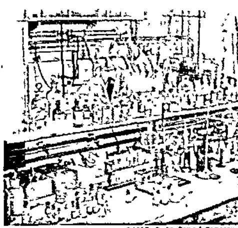
Many nineteenth centu
helped build this science of d
of the most prominent co
Francis Magendie and Otto

In ancient times and unt
tury, knowledge of how DRU
was unreliable. The sciences
chemistry were still undevel
tion and magic influenced e
and herb collectors. They
"books of medicines" call
poeias, and these books recom
drugs that were either worth
ful, when examined by the
modern pharmacology. For e
dered dandelion root was liste
copoeia books, and was clai
colds, kidney stones, and dee

On the other hand such me
as the medieval herb-extract
plants, called DIGITALIS, has
to contain the curative chemi
and this purified drug is now p
certain heart ailments. A simila
of the use of an old herb disc
South American Indians—the
cinchona tree containing quini



The development of biological serums started about 1894 with the use of diphtheria toxin



About 1920, Fourneau of France produced many compounds to fight specific diseases

to the modern use of purified quinine to treat malaria. Quinine has been further studied by pharmacologists, and a successful man-made drug, atabrine, has been created which is even better than quinine for treating malaria.

THE BRANCHES OF PHARMACOLOGY

Four branches of the science are recognized: *Pharmacodynamics* deals with finding how chemicals act on men's bodies, or first on those of laboratory animals.

Chemotherapy includes two studies: (a) how drug chemicals can destroy invading germs, and (b) how to restore normal health to unbalanced organs and glands. The *antibiotic* drugs (sulfa chemicals, etc.) are such gifts of chemotherapy to the conquest of many human bacterial diseases. Some antibiotics act, not directly to kill germs, but indirectly by stimulating body cells to fight germs. Some act in both ways. Another product of chemotherapy is the hormone *insulin*, an extract of the pancreatic glands of cattle, which has saved the lives of millions of people sick with diabetes.

Clinical pharmacology is practiced by research doctors in hospital clinics. After the pharmacodynamic action of a new drug has been determined, that chemical becomes ready for testing on volunteer patients. In the clinic the researcher makes tests to learn if safe doses will cure or relieve the disease which it was intended to help.

The fourth branch of drug science, *toxicology*, is studied to determine how especially poisonous (toxic) chemicals act on living things. The study includes the search for antidotes and for other ways of preventing injury by poisons. As example, there is the recently-discovered chemical that taken as a pill to relieve the pai[illegible] rash of poison ivy.

MEDICINE DOSAGE BECOMES MORE SCIENTIFIC

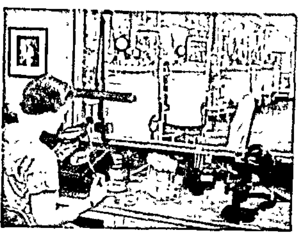
Doctors have long been concerned about how to find the correct dose of a medicine Pharmacologists have recently created an ingenious way to test and record drug doses.

Suppose that an entirely new chemical with some curative effect is discovered. The drug scientist first tests and records all the doses which were administered to laboratory animals and later to human volunteers. Then he reports to the waiting world of drug manufacturers and physicians just what the best doses and effects are. To do this, he reports the *effective dose response* (ED), meaning that dose required to produce one-half (50%) of its observed curing effect. For example, for ASPIRIN to relieve a fever due to a cold, might be reported: "Aspirin, anti-febrile, ED_{50} dose 2.5 grains every 2 hours, per 150-pound adult body weight." The full dose for an adult this size would be 5 grains. (A grain is equal to 0.0648 grams.)

This manner of stating dosage allows for individual differences in drug sensitivity.

METHODS OF DRUG STUDY

Good drug-action research usually follows certain accepted methods. Laboratory animals are given measured doses of a promising chemical. The bodily effects on the animals are accurately observed. Then perhaps certain bad effects of the drug cause the researcher to seek a related but slightly changed chemical. Often the researcher will go to a fellow organic chemist and ask for a similar chemical that has only one atom or a small molecular group of atoms changed. The new chemical is then given in measured doses to animals. This process [illegible] for many months until a drug [illegible] that is satisfactory. It is then



Since the discovery of penicillin, the synthesis of antibiotics has become vitally important

Continuous research in pharmaceuticals is the most important task of pharmacologists

ready to be tried on volunteer clinical patients. In this very way, the old herbal drug, salicylic acid, was rejected for the much-improved acetylsalicylic acid, which is commonly known as ASPIRIN.

NUCLEAR ENERGY ISOTOPES

Since World War II, pharmacology has found a powerful new discovery tool in radioisotopes. For example, radio-carbon-14 and radio-iodine, which are both products of nuclear energy reactors, can be chemically added to drugs and fed to laboratory animals or to man. These radioactive chemicals become *tracers*, so-called because their paths in the body can be followed by the detecting electronic radiation counters or by photographs. Thus an animal that is fed radio-iodine will later show a "hot" radiation area right in the iodine-hungry thyroid gland area of its neck.

The curing values of most medicines is owed to pharmacologists. The earliest discovered antibiotic, PENICILLIN, was first detected only as a crude, green mold (*Penicillium notatum*) by Sir Alexander Fleming in 1928. Only after he and many pharmacologists studied this mold for more than ten years was the pure chemical, penicillin, finally given to the world. D. A. B.

SEE ALSO: MEDICINE, PHYSIOLOGY

Pharynx (FAIR-ingks) The pharynx is the section of the alimentary tract of some invertebrates connecting the mouth and esophagus. In vertebrates, it is the tube back of the nose and mouth where air crosses the path of [illegible] going to the esophagus.

SEE: ADENOID, DIGESTIVE SYSTEM, RESPIRATORY SYSTEM

Phases of the Moon see Earth; Moon, phases of

Pheasant The male pheasant is one of the most colorful of all game birds. The female is not as pretty. Hunters like the pheasant both for its colorful feathers and for its flavorful meat. It is protected by game laws.

The ring-necked pheasant is the most popular in the United States. It is a hybrid, a cross between the Chinese ring-necked variety and the common English pheasant.

Pheasants can run with great speed on their long legs. They can fly for short distances but only with effort because their wings are short. Their wings are, however, wide and the bird can glide for great distances. The male has a beautiful multi-colored tail. V. V. N.

Male ring-necked pheasant

Phenols The phenols are a group of organic compounds which have one or more HYDROXYL groups (OH) attached directly to an aromatic-ring system. The simplest is phenol (C_6H_5OH). They are used in disinfectants, plastics, and preservatives
SEE: ORGANIC COMPOUNDS

Philodendron

Philodendron The philodendron is a common house plant. It is an interesting VINE, because it grows rapidly and is decorative whether it is trained to climp up or to trail down.

The leaves of the philodendron are large, bright green, and somewhat heart-shaped It does not need much sun and is an excellent plant to place in a north or west window It needs much moisture Stems that include a node may be placed in a container of water, and they will root It is wise to add a small amount of house plant food to the water

The philodendron, if properly cared for, will live a long time Its large leaves should be washed from time to time

J. K. K.

Phloem (FLO-emm) Inside a plant are groups of cells which carry on a particular job for the plant. Phloem makes up conducting tubes for the purpose of carrying the manufactured food to all parts of the plant. Phloem ells are found around the outside of YLEM cells, the other kind of conucting tissue.

There are several kinds of cells in phloem renchyma are large thin-walled storage ls *Fibers* have thick walls to give the nt support and strength. *Sieve tubes* are

Four types of

elongated cells which re but lose their nuclei Th companion cells to help t constant flow of solutions cell may weaken the cross them to be perforated as a s

Phloem tissue in trees mak part of the BARK It is sepa xylem tissue by a sheath of cells called *vascular cambium* constantly divides and forms and xylem cells every year
SEE ALSO PLANT TISSUES

Phlox (FLOCKS) Phlox is that will bloom all summer Th kind, no more than six inch can be found in many rock ga Another higher variety is used border herb The blooms are commonly white or pink to pu

This annual or perennial plant grow a creeping manner or in an erect posit The leaves are alternate in arrangem with a smooth margin The petals of t flower are fused to form a tube with t outer edges scalloped The flower is perfec meaning it has both male and female re productive structures Many hybrid vari ties now come fringed or star-shaped in a wide range of flaming colors

In late fall or early spring, the mature plant should be dug up, the rootstock cut into several pieces and replanted over a wider area This is referred to as multiplication of a flower bed by division If phlox is permitted to reseed itself, the offspring will revert to the wild state

H. J. C.

Phoebe see Peewee

Globe phlox

Phosphate Phosphate is the name given to the large series of chemical compounds which have as part of their formula a phosphate component. Of all the phosphate compounds, the most common are the ammonium, calcium and sodium salts of phosphoric acid. Any phosphate has PO_4 in its formula.

The most familiar phosphate compounds are inorganic and are used in large quantities in many industries. For example, *diammonium phosphate* is used as a fireproofing agent for textiles. *Monoammonium phosphate* is used in baking powders. *Monocalcium phosphate* is used as a dietary supplement in animal feeds, and the various sodium phosphates are used as laxatives, as buffering agents, and in detergent mixtures. M. S.

SEE ALSO: PHOSPHORUS, SALT

A lantern fish has organs which produce a phosphorescent glow

Phosphorescence (foss-for-ESS-sense) Phosphorescence is the condition in which certain organic or mineral matter and certain plants and animals give off light without the presence of heat. Also known as "afterglow," phosphorescence has been known to persist for a period of only a few seconds up to several days.

The scientific explanation of phosphorescence is that the substance absorbs radiant light energy which increases the energy of some of the electrons in the substance. When the electrons slowly return to their original state, they emit this extra energy in the form of light. If the radiation of a substance fades immediately after the light is stopped, the process is called *fluorescence*. If light continues, however, the process is called

In ancient times, phosphorescence was, of seen and recorded as it appeared in nature. However, the earliest record of serious investigation and experimentation of this phenomenon comes from Bologna, Italy, where a cobbler and alchemist named Cascariola conducted extensive research with a barium compound.

The delayed luminescence of phosphorescence is the result of the object being subjected to an exciting light source. The time during which phosphorescence persists is known to decrease with an increase in temperature of the substance. The principles of phosphorescence are being applied in many new areas of research, using especially the highly phosphorescent ruby. D. A. B.

SEE ALSO: BULB, ELECTRIC

Phosphorus (FOHS-fuh-ruhs) Phosphorus is an element that is found in four different pure forms. Each form has different characteristics. Chemically it is a non-metal, related in its properties to the elements nitrogen and astatine.

Phosphorus was first isolated in 1669 by H. Brandt. It is the first element whose date of discovery is known. Brandt isolated phosphorus from animal urine. Phosphorus occurs in compound form in all fertile soils. It is necessary for all plant and animal life. In man it is found mainly in bones, teeth, muscles, and nervous tissues.

The most common form of phosphorus is a yellow waxy solid. This form is originally white, almost colorless, but turns yellow when exposed to light. Yellow phosphorus melts at 111.6° F, is extremely poisonous, and must be stored and cut underwater to prevent fire. When moist yellow phosphorus is exposed to air, it burns, forms phosphorus pentoxide, and gives off a glow from the heat generated. This glow is a chemical change and is unrelated to phosphorescence. The only similarity between phosphorus and phosphorescence is in the word root *phosphor* which means "light bearer."

Red phosphorus, another form, is widely used in making safety MATCHES. Red phosphorus is produced by heating yellow phosphorus or exposing it to a bright light. It is

A glow and heat are produced when phosphorus is exposed to air

not poisonous and must reach 500° F to burn. Red phosphorus is used in making bronzes and medicines and in gas analysis.

There are other forms of phosphorus, named for their colors, black, scarlet, and violet. Scarlet phosphorus is produced by dissolving yellow phosphorus in phosphorus tribromide and heating it to 357° F The solid scarlet phosphorus then settles out. Violet or metallic phosphorus is produced by heating red phosphorus in contact with lead for ten hours at 932° F. The phosphorus dissolves in the lead and upon cooling it separates as violet phosphorus.

Phosphorus for commercial purposes is obtained from rock PHOSPHATE, a phosphorus-rich mineral. Rock phosphate is purified by heating with sand and carbon. France and the United States are the largest producers of rock phosphate. Phosphorus is the eleventh most abundant element.

Phosphorus (symbol P) has an atomic number of 15. Its atomic weight is 30.9738 (30.975, O = 16).

SEE ALSO: ATOM, ELEMENTS J. K. L.

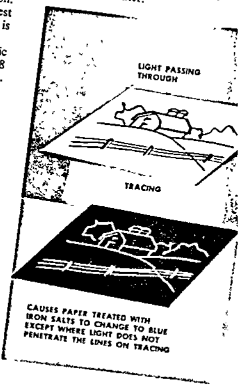
Photochemistry Photochemistry is the study of chemical changes involving light. It studies those processes in which light causes chemical changes. Also it studies the reverse processes n which chemicals react to emit light. *'hoto* is from Greek meaning "light."

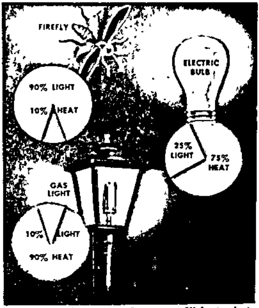
Photochemical processes of the first pe are illustrated by what happens a film when a picture is being taken, d by the whitening of dark-colored ɪthing or hair when exposed to sunɪt. Examples of the second type are strated by the flashing of a firefly the burning of candles or oil and lamps.

In nature, an important change occurs in green plants in the cells of green plants us bine ordinary water and c chemically to make sugar Th cal process is called PHOTOSY

Photochemistry is basic to developing of photographic fi plastic film is coated with gela ing tiny grains of silver bromid film is placed in a camera a focused on it through the shutt the silver bromide undergoe changes in those spots where lig The grains in these spots are said *sitized.* Chemical developers r sensitized grains of silver bromide silver. Chemicals called *fixers* are to remove the silver bromide whic sensitized.

BLUEPRINT paper is photochemic lar to film. But for blueprints, coated with iron-ammonium citr ferrocyanides. Light changes these p salts to deep blue ferric ferrocyanid veloping an exposed print only r washing it in water.





The firefly has a much more efficient photochemical process of light than does any of the light sources which man has been able to devise. Much less heat is produced for the amount of light given off

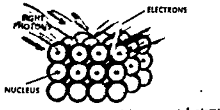
CHEMICAL PRODUCTION OF LIGHT

The oldest known photochemical change is that of burning fuels. Candles and gas or oil lamps are such light-giving devices. Even the best modern kerosene lamp is photochemically wasteful, since nine-tenths of the chemical energy in the original fuel is changed to heat and less than one-tenth to light. Even an electric light bulb wastes about 75 per cent of the original electrical energy as heat.

The reverse photochemical change has been difficult for man to produce. In nature, the firefly (lightning bug) has long been admired by scientists. In his laboratories, man has never yet found chemicals that give light matching the efficiency and coldness of the firefly's light.

Besides fireflies, many other living things perform photochemical feats. Fox fire is the glowing of decaying fallen logs, caused by bacteria that decompose the wood. Several kinds of sea animals produce light. The scallops (*Pectens*), clam-like animals that propel themselves by flapping their shells, have rows of phosphorescent eye spots lin-
g the outer edges of their shells. When a
'op rests with its shell agape, small prey
lured into the scallop's vise-like shell
].

D. A. B.



The outermost electrons of heavy metal atoms have weak binding force. They can be knocked loose by light and utilized as photoelectrical energy

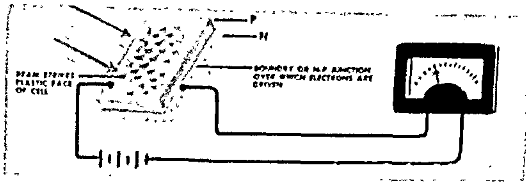
Photoelectricity Photoelectricity is the study of how light and electricity work together. It has made possible the "electric eye" which automatically opens the doors of the supermarket, counts the number of articles made each hour in factories, and measures the brightness of distant stars. Even cameras now adjust themselves with its aid.

Light sometimes acts as though it were a stream of particles instead of waves. The brightness of the light is determined by the number of these particles, or PHOTONS, in the beam, while the energy of each individual particle determines what is called the *color* of the light.

Metals, like all matter, are made up of atoms. These, in turn, consist of a dense, positively-charged nucleus surrounded by a cloud of electrons. It is the electron's negative charge which binds it to the nucleus by electric-field attraction.

Since the atoms of most metals are relatively large, the outermost electrons are relatively far from the nucleus. As a result, the binding force upon these outer electrons is quite weak. When metal atoms are linked together to form a solid, the outer electrons can move freely anywhere in the solid and are called conduction electrons. If a photon of light is absorbed by a conduction electron, the additional energy may be enough to drive that electron out of the metal surface. When electrons are driven out continuously by light falling on a metal surface, a voltage can be applied between the surface and an electrode and the photoelectrons collected.

One of the major types of phototubes includes a semi-cylindrical CATHODE that has its inner surface coated with a light-sensitive alloy of cesium and silver. The anode is a



A system may be designed to operate a meter which measures the brightness of light

forms: (1) an "N material," and (2) a "P material." A single crystal of silicon is treated in both ways so that a boundary forms between them. This boundary is called a "P-N" semiconductor junction.

When a P-N semiconductor junction is connected, only a small current can flow across it in the dark, because the battery acts to prevent the free electrons in the N material from moving across into the P material. But when light photons strike the junction, they give some electrons enough additional energy to overcome the opposition and cross over. Thus the current through the semiconductor will tend to increase in proportion to *the brightness of the light striking it. This is* the principle of the phototransistor and of other semiconductor light-sensitive devices.

The N-P-N junction transistor in a semiconductor photoelectric relay is normally in a practically nonconducting state, as is the phototransistor when in the dark. Light photons, striking the P-N junction of the phototransistor, cause it to pass current into the base of the N-P-N unit, which then also conducts strongly enough to magnetize the relay coil and close the system contacts.

In addition to an "off-on" switching operation as described, the photoelectric device can also measure light of smoothly varying intensity. The photographer's light meter makes use of a copper-oxide, or similar photovoltaic cell. Here the photons give their energy to loosely-bound electrons and develop a proportional electrical voltage, just like a battery, between a copper plate and an overlying thin layer of copper oxide. This voltage, proportional to the intensity of the light, operates a sensitive millivoltmeter calibrated in light intensity. A similar device controls the lens opening in the automatic camera. An electron phototube *and amplifier, similar to that first described,* is used by astronomers to measure the light from distant stars.

As interesting as these and many other applications of photoelectricity seem, the science of photoelectricity has revealed more of the nature of light and of matter than would have been possible with the knowledge and equipment available before. C. F. R.

SEE ALSO: AUTOMATION, ELECTRICITY, ELECTRONICS, LIGHT, PHOTOCHEMISTRY, TELEVISION, TRANSISTOR, VACUUM TUBE

A photoelectric circuit can be utilized to do tasks around the home

greenhouse shutters
is too strong
shutters when sky is cloudy

Photography Photography is the process of producing images on a surface. Basic to the entire process is the chemical reaction of certain substances to light. Light rays affect things in different ways: skin turns red, colors often fade, grass and flowers grow.

About 150 years ago, chemists discovered that silver salts (combinations of silver and bromine or silver and chlorine) were affected by light. They found that if they put a coating of silver salt on a glass plate, or transparent paper, the light would affect the silver salts so that an invisible change took place where the light hit. If this paper or plate were then bathed in a special solution, the change could be made visible where the silver salt changed into silver. The untouched silver salt could then be dissolved in another solution and only the parts changed by light would remain.

One of the earlier processes, becoming popular around 1839, was introduced by a French inventor, L. J. M. Daguerre. He made use of silver plates or copper plates coated with silver, on which photographs were produced. These photographs were called *daguerreotypes*, and were sometimes called *tintypes*.

THE PHOTOGRAPHIC PROCESS

Light source: Light from the sun or a flash bulb falls on the object to be photographed. The object reflects some of the light rays and absorbs some of them. The lighter colors reflect more of the light rays.

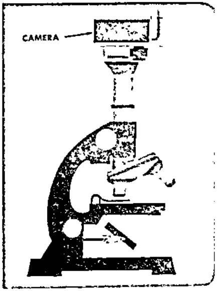
Camera: The pattern of reflected light rays from the object is focused by the camera's lens on a film coated with silver salts. The camera must be light-tight so no other light rays can enter.

Film: A latent (invisible) image of the object is impressed upon the film by the reaction of the silver salts to the light rays.

Negative: Three solutions are needed in a darkroom. The picture, or visible image, is brought out when the film is placed in a *developer* solution; another solution stops any further development; a third solution, or *fixer*, dissolves the silver salt which has not been affected by light. In these three solutions, a "negative" picture is made. The white objects look black, the blacks are clear.

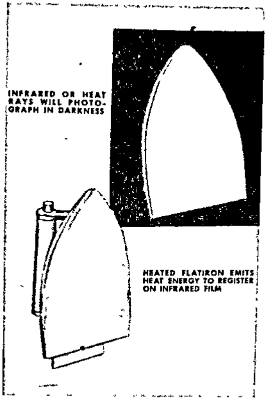
✳ THINGS TO DO

TAKING PICTURES THROUGH A MICROSCOPE



1. **Place a microscopic slide under the objective on the stage of the microscope. Direct as much light as possible upon the specimen to be photographed.**
2. **Using electricians' tape, seal the lens opening of the camera directly over the eyepiece of the microscope.**
3. **Set the range finder on infinity. While taking the picture be careful not to jar the instruments.**
4. **Microphotography takes patience, experience, and a knowledge of general photography.**

Prints: Light must pass through the negative to shine on paper coated with silver salt in the same manner as the film. Again a latent image is formed, which is then developed and fixed. The black objects now look white, as in the original, and the clear areas, where the light penetrates and hits the paper, are dark. If the negative is placed directly against the printing paper, the process is called *contact printing*. This is used for much amateur photography. Enlargements are made by projecting the light through the negative onto the printing paper some distance away.



VARIATIONS IN THE PHOTOGRAPHIC PROCESS

Art: By special lighting, light filters, camera lenses, exposure times, developing and printing techniques, a great many different effects can be created in photography. The subject matter may be so emphasized that artistic relationships and interesting compositional arrangements are achieved.

Photoengraving: A negative is made by taking a picture of a drawing or photograph. An image is produced on a coated metal plate, which is then etched by acid, the acid affecting the parts of the plate unaffected by light in the PRINTING process. When inked and printed, the etched-away areas are the light areas.

Photomicrography involves taking pictures of the images produced by a microscope.

Astronomical photography uses lenses of large diameter and long exposure times to capture the faint light from distant stars.

Underwater photography requires special water-and-pressure-proof cameras and special lighting for depths below twenty feet.

Spectrography is photography using infrared, ultraviolet, and X-ray films which have ...itized to wave lengths shorter or ...an those of the visible spectrum. ...eed photography employs a very bright flash, powered electronically, extremely short exposure times, and very sensitive "fast" film. Such rapidly moving objects as revolving wheels and the beating of insect wings can be photographed at high speed, then slowed down for viewing.

Aerial photography uses multiple lenses and high-speed shutters to take pictures of the ground for map making.

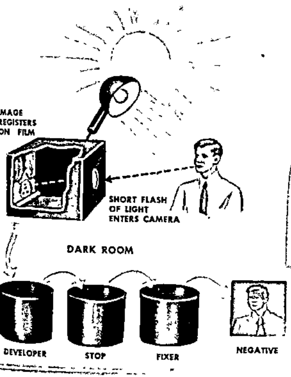
PHOTOGRAPHIC THEORY

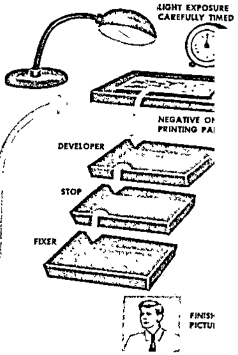
In ordinary negative processing, the most common developers are *hydroquinone* and *monomethylparaminophenol* (trade names Elon, Metol). Developers are able to distinguish between the exposed and unexposed silver halide and convert the exposed halide to silver. Fixing solutions of *sodium* or *ammonium thiosulfate* (hypo and ammonium hypo) then dissolve out the unchanged silver halide.

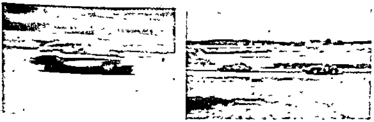
It is possible to treat the film in the camera so that the final result is a positive instead of a negative. This is called *photographic reversal* and is used in some motion picture and color photography. Here the film is placed first in the developer, then in a solution of *potassium dichromate* acidified with sulfuric acid, which will dissolve the developed negative silver image, but not affect the undeveloped silver halide. After exposure to light, a positive image is produced from the remaining silver halide by developing it a second time. Thus the same film that was in the camera becomes the positive. In MOTION PICTURES, light shines through the moving positive film to reproduce the original scene—enlarged—on a screen.

Color photography involves the use of a special film containing three separate layers which record the red, blue, and green wave lengths of the visible spectrum. Because all colors can be made of mixtures of red, blue, and green, they are called *primary* colors. Color film can be developed by the reversal process, producing positive transparencies which are viewed by projection. Another kind of color film is developed so that the negative shows the opposite color values; red looks blue-green, blue looks yellow, green looks magenta. The printing process reproduces the original colors. H. W. M.

SEE ALSO: LENS, MAN-MADE; OCEANOGRAPHY; PHOTOCHEMISTRY; PHOTOMETER; SPECTROSCOPE; TELESCOPE; X-RAY



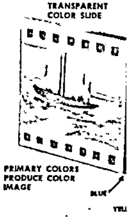


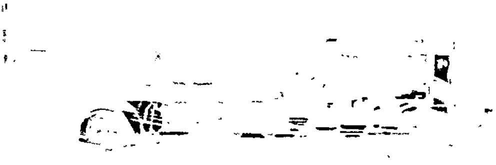


For still camera
A. Improper setting for high speed

B. Proper setting for high speed

For motion picture, in viewing, A can be slowed down to appear as B.





X-RAY PHOTOGRAPH OF A JEEP

Phylogeny (fi-LOJ-eh-neye) Phylogeny is the history of the development, or EVOLUTION, of a species, family, or larger group of animals or plants from the simplest form to the most complex.

SEE: ANIMALS, CLASSIFICATION OF; EVOLUTION OF MAN; PLANTS, CLASSIFICATION OF

Physical states and changes Physical states and changes involve the study of matter. All MATTER takes up space and has weight. All matter has three physical states: solid, liquid and gas. Heat, or the lack of heat, changes matter from one state to another. Water can exist in three different states. Water in the form of ice in a refrigerator is in its solid physical state. Water coming from a faucet is in its liquid physical state. Water boiling in a tea pot turns to steam, its gaseous physical state. Through all these physical changes, the substance itself—water—remains the same.

Matter can neither be created nor destroyed by ordinary means. The physical states of matter can be changed or matter can be combined with other forms of matter to make new substances. When matter changes its physical state, the scientist refers to it as a *physical change*. When kinds of matter combine with one another to form a new material, the scientist refers to it as a *chemical change*.

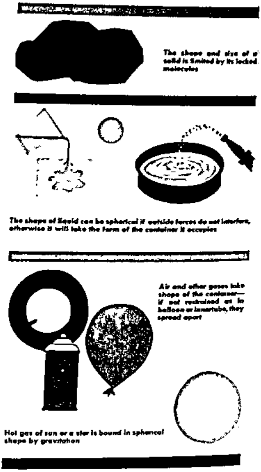
All matter, solid, liquid or gas, is alike in two ways. A block of wood, a glass of water, or air, all occupy space. Air, and other gases, may appear not to take up space. However, if a drinking glass is turned over and pressed down in a bowl of water, water will enter the glass only part way because the air in the glass does occupy space. The space occupied by a material is called its *volume*. All material has weight. Solids, such as a brick, or liquids, such as water in a bucket, obviously have weight. That air has weight is shown by the difference in weights of a deflated and an inflated basketball.

Solids are different from liquids and gases in two ways. Solids have the characteristics of keeping a definite shape and having a definite volume. A pencil or a brick do not change shape by themselves, nor do they change the amount of space they occupy.

Liquids, like solids, take up a given amount of volume. A glass of milk occupies a certain amount of space, but if the milk is poured into a pan, it takes the shape of the pan. A liquid, not having a shape of its own, takes the shape of the container it fills. Therefore, a liquid has volume, but no constant shape.

Gas has no form of its own. Air in a covered drinking glass takes the shape of the glass. A gas does not occupy a definite amount of space. Air in a bottle, if uncorked, spreads into the room. A gas, then, is matter in a state in which it has no definite shape nor volume. Gases will expand to fill any container.

Very often matter in one state is com-

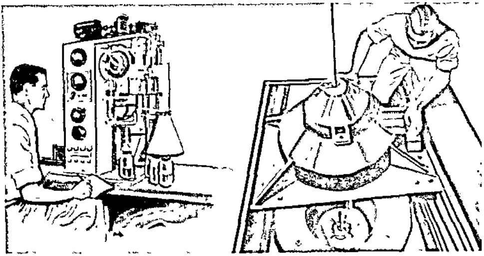


The shape and size of a solid is limited by its locked molecules

The shape of liquid can be spherical if outside forces do not interfere, otherwise it will take the form of the container it occupies

Air and other gases take shape of the container—if not restrained as in balloon or innertube, they spread apart

Hot gas of sun or a star is bound in spherical shape by gravitation



Special apparatus, such as a molecular still (left), perform operations in molecular researc[h]. Substances to be irradiated are placed inside a nuclear radiation chamber (right) with a high radioactive sample. The chamber is an aid to physicists in their study of radiation

bined with matter in another state. Mixing sugar into lemonade combines a liquid material with a solid material. In a solution these things happen. First, the liquid in a solution is clear and free of particles. Secondly, the dissolved material can pass through the finest of filters which allows the liquid to pass. The dissolved material cannot be filtered out. Thirdly, the dissolved material spreads evenly throughout the solution medium.

Some solid materials added to a liquid do not go into solution, but are suspended in the liquid. Starch and water when combined do not form a solution. Rather, a suspension of the starch particles occurs.

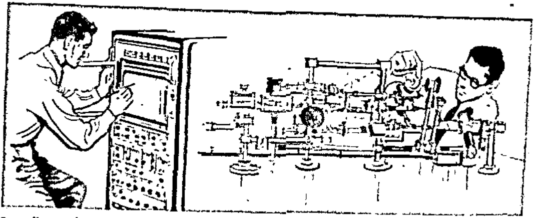
Changes from one physical state to another can occur by heating or by taking away heat. When a solid is heated enough, it changes to a liquid. For example, a piece of aluminum melts when heated to 1220° F. Liquids, when heated enough, change to gases. Water changes to steam at 212° F. Liquids may also evaporate at low temperatures. For example, water evaporates from wet clothes hanging on a line.

Cooling the materials of each state of matter reverses the physical changes. Gas will turn to a liquid, and liquid, when cooled enough, will become a solid. P. F. D.

SEE ALSO: ATOM, CHEMICAL CHANGE, CHEMISTRY, EVAPORATION, GAS, HEAT, LIQUID, MOLECULAR THEORY, PHYSICS, SOLID, SOLUBLE, SOLUTION

Physics (FIZZ-icks) Physics is th[e] science dealing with matter and ene[r]gy. MATTER is anything which occu[]pies space and has weight. ENERGY i[s] the ability to do work. There are man[y] kinds of energy such as light, sounc[d], electrical, heat, and mechanical ene[r]gy. Physics is an exact science whic[h] requires careful measurement of man[y] quantities.

MATHEMATICS is an important too[l] in the study of physics. The science i[s] concerned with the natural laws whic[h] govern the environment of man an[d] theories about the behavior of ma[t]ter. The pull of GRAVITY which cause[s] weight is an illustration of the Unive[r]sal Law of Gravitation, an importan[t] law in physics. Theories may chang[e] when experiments give new evidenc[e] about the nature of matter. Atomi[c] theory illustrates how a theory may b[e] modified. At first, atoms of matte[r] were thought to contain only a fe[w] particles. Now atomic theory mus[t] account for over twenty different par[]ticles which have been discovered.



Recording and measuring instruments are designed to study substances under varied conditions. Specialized instruments and equipment enable the physicist to determine the nature of matter

Physics usually covers the subjects of mechanics, heat, sound, light, magnetism, electricity, and modern physics. MECHANICS involves a broad area of knowledge, especially the topics of motion, force, energy, solids, liquids, and gases. Mechanics includes a study of many fundamental quantities and their measurement. These include the concepts of mass, weight, density, and volume. Some of these are *vector quantities* which have not only numerical value but a definite direction. Weight, the pull of gravity on an object, is directed toward the earth and illustrates a vector quantity. MASS refers to the amount of matter in an object and is not a VECTOR, or directional, quantity. Mass would not change even if gravity changed. Studies of potential and kinetic energy are part of mechanics. *Potential* energy is stored-up energy, such as water in a dam. The energy becomes *kinetic* when the water flows over the dam to run a HYDROELECTRIC POWER plant.

HEAT, another form of energy, includes study of its nature and behavior. The quantity of heat a body contains is measured in calories or British Thermal Units. Temperature indicates the intensity of heat but not its quantity. In terms of the MOLECULAR THEORY of heat, temperature is the average kinetic energy of the molecules of matter, but the quantity of heat is the total kinetic energy. Studies of RADIATION, conduction, and convection are included as methods of heat transfer.

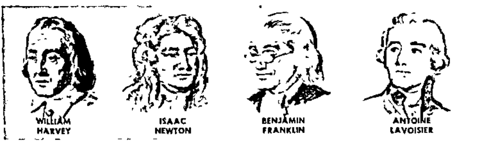
The physics of SOUND concerns how sounds are produced and transmitted. Energy is required to make objects vibrate and send out sound waves. Sound waves are longitudinal, and in air, air particles vibrate back and forth in the same direction as the sound wave travels. The study of sound includes the special properties of musical sounds—pitch, loudness, and quality.

LIGHT as a form of energy requires two theories to fully explain its behavior. The *wave theory* of light holds for light as a transverse wave motion, an electromagnetic wave, which travels with a velocity of 186,000 miles per second. The *quantum theory* explains how atoms absorb and emit light energy. The energy is given off or taken up in small bundles rather than in a continuous manner.

ELECTRICITY is another broad area of physics. It includes a study of electric charges, magnetism, and current electricity. Electricity is used in many electrical devices such as motors, generators, batteries, transformers, and electronic equipment.

Rapid advances in physics in recent decades have occurred in atomic and nuclear physics. This area includes electrical discharge in gases, electromagnetic and spectral series, and X-rays. Research in NUCLEAR ENERGY, radioactivity, and atomic disintegration has brought dramatic results. The atomic bomb demonstrated how tremendous amounts of energy may be released when a small amount of matter is converted into energy.

There are also specialized areas in physics dealing with physical properties of living matter. BIOPHYSICS is the study of living things using the methods and tools of physics. The theories and facts of physics are so basic they are involved in almost every other science. I. M.



Physiology Physiology is the study of how living structures work. For example, in order to keep alive, all living things get ENERGY from food. They *grow and reproduce new living forms* just like themselves. They react to the world around them, and try to adjust to changes. As plant and animal life becomes larger and more complicated, the different parts of a body must be coordinated so they work together. Physiology studies these processes.

Because the scientist must first understand how a thing is made, before he can understand how it works, a physiologist studies the various parts of the living structure—its ANATOMY. He studies the functioning of the structure. He may study how an individual NERVE CELL sends an impulse, how the muscles of the body move together, or why a plant produces flowers at certain times of the year. But to have an understanding of the building materials of living things and the natural laws governing them, a physiologist must also know the basic PHYSICS and CHEMISTRY of the nonliving world, as well as the biophysics and biochemistry of living structures.

For example a boy or girl eats food and grows bigger. The physiologist checks digestion, circulation, elimination, metabolism, respiration, and excretion to find out what is happening to the food inside the person's body.

DIGESTION

When food enters the mouth, it is chewed by the teeth into small pieces, mixed with saliva produced by the salivary glands, and passed down the esophagus into the stomach. Once in the stomach, an acid mixture of enzymes begins the digestion of the food

THREE CENTURIES OF DISCOVERY IN PHYSIOLOGY AND IN FIELDS THAT HELP IT

1600 Fabricius (Italy) studies human anatomy and writes book *About Venous Valves;* (teacher of Harvey)

1628 William Harvey (England) publishes *Motion of the Heart and Blood*

1650 Robert Boyle (Ireland-England) invents air pumps and studies lung-pressure

1656 Thomas Wharton (England) is first to study gland physiology

1661 *Malpighi (Italy) describes mechanism of* breathing; later studies kidney secretion

1670 Borelli (Italy) studies the physics of animal movement

1687 Isaac Newton (England) publishes his *Principles that lay the foundation for all exact* sciences

1688 Leeuwenhoek (Holland) discovers capillaries with his microscope

1733 Stephen Hales (England) writes about blood pressure

1752 Benjamin Franklin (U.S.A.) shows that lightning is electricity; shows some electrostatic actions on the body

1774 Joseph Priestley (England) discovers oxygen

1777 Spallanzani (Italy) studies how foods digest—in test tubes

1780 Antoine Lavoisier (France) refines Priestley's ideas about air and oxygen; and shows similarity of burning and breathing

by chemical action, and the mechanical churning of the muscular stomach wall aids in this digestion. When the food has been broken down into a thick, soupy liquid, it passes through an opening into the small intestine a little at a time. In the small intestine the most important part of digestion begins. First, the acid solution is made slightly alkaline. Separate ENZYMES, which are specific in their action, are secreted by the cells of the intestinal wall and pancreas. These enzymes break down starches into sugar, fats into glycerol and fatty acids, proteins into amino acids. The liver forms a substance to break fat into small droplets. Secretions from pancreas and liver reach the small intestine through ducts. The coordination of all this enzyme activity is controlled by hormones circulating in the blood.

CIRCULATION

When all the large molecules of food have been reduced to small molecules by digestion, the particular substances that the body needs to build new tissue are available. First, however, these small molecules must be taken inside the cells throughout all parts of the body, for it is within each small cell that new tissue is made. From the digestive tract the blood receives the small molecules that can be used as building blocks for new tissue, and transports them through the body. They travel through the network of blood and lymph vessels, and are propelled by the pumping action of the heart.

ELIMINATION

The part of the food that cannot be used by the body passes from the small intestine into the large intestine and rectum. It is discarded as feces after such important substances as water and vitamin K have been restored to the body.

METABOLISM

Once the small molecular building blocks are brought within the cells of the body, the formation of new tissue begins. Hormones circulating through the blood regulate the amount and kind of tissue formation and the places in the body where new tissue will be formed. The chromatin material in the nucleus of each cell provides the pattern of tissue formation and the enzymes that make it possible.

When a person is little, the growth hormone of the PITUITARY gland stimulates a [illegible] rate of protein synthesis and, consequently, rapid growth. As he reaches PUBERTY, the long bones of the body and the masses of muscle tissue are conspicuous areas of growth. When he becomes an adult, the amount of new tissue formed is normally only enough to keep pace with the damage produced during the wear and tear of living.

RESPIRATION

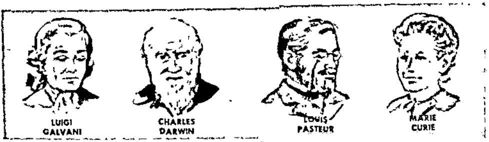
In order to make new tissue, there must be energy provided by the body to link together the small building blocks into those particular large molecules needed by the body. There are definite chemical reactions that take place in the cell and provide this energy. These reactions require oxygen, which is obtained from the air by respiration. To bring oxygen to the cell, the boy's lungs, aided by the muscular action of the diaphragm and the chest muscles, breathe in air. Once again, it is the pumping action of the heart that drives the oxygen-bearing blood through the body to reach each individual cell. The respiratory muscles are controlled by the brain, and function automatically without the boy's being consciously aware of doing this work. Indeed, many parts of the body function automatically in this way, and free large areas of the brain for observing and evaluating the outside world.

EXCRETION

The creation of energy and the synthesis of new tissue results in wastes that must be removed from the body. If these wastes remain in the body, they poison it. The liver detoxicates nitrogenous wastes, and these products are then carried by the blood stream to the kidney for removal as urine. The water balance of the body is a crucial physiological necessity, and this balance is maintained by the functioning of the kidney and supervised by endocrine hormones.

ADAPTATION

The delicate physiological balance (*homeostasis*) needed by the body for it to function properly is a never-ending study. As the biochemical reactions proceed within the body—the processes of digestion, respiration, muscular activity, or secretion of hormones—new products accumulate, and old reserves of raw material are used up. There are continuous changes going on inside the body, and adjustments must be made continuously to preserve the conditions neces-



sary for life. These adaptations are, for the most part, set into motion by the nervous system and the endocrine secretions.

Outside the body, changes are also influencing the physiology. If the aroma of food reaches the hungry boy's nostrils, he gets ready to eat. If he is riding his bicycle and loses his balance around a curve in the road, the nervous system and muscles cooperate to keep him from falling and injuring himself. If it suddenly becomes cold, the nervous system alerts the boy to put on warmer clothing If infectious germs enter the body, the defenses of inflammation, reaction, and *phagocytosis* go to work.

These physiological processes proceed in every living organism, whether it is a one-celled body or a complex many-celled body. The simpler the organism, of course, the less elaborate the mechanisms necessary to sustain life.

For example, a one-celled alga plant is able to take in food and release wastes by means of its semipermeable cell membrane. Simple diffusion circulates the particles within the cell. In the earthworm there are many cells, and although the animal is relatively small in size, it still requires a special network of tissues to distribute nourishment and remove wastes. The human body has evolved complex organ systems to insure nutrition, waste removal, and physiological harmony.

Indeed, all the systems involved in physiology are so complex that research proceeds continually to discover the secrets of life that still elude man's understanding. B. B. G.

SEE ALSO: ADAPTATION, CIRCULATORY SYSTEM, DIGESTIVE SYSTEM, ENDOCRINE GLANDS, EXCRETORY SYSTEM, HISTOLOGY, HOMEOSTASIS, METABOLISM, MUSCLE SYSTEM, NERVOUS SYSTEM, NUTRITION, REPRODUCTIVE SYSTEMS, RESPIRATORY SYSTEM, SENSE ORGANS, STRESS

1791 Luigi Galvani (Italy) discovers the effect of electricity on muscles

1796 Edward Jenner (England) successfully uses first vaccine and immunizes people against smallpox

1810 Franz Gall (Germany) offers first theory of brain action; led to now discredited phrenology

1821 Magendie (France) experiments on nerves acting on muscles and glands

1833 Wm. Beaumont (U S A.) army surgeon works with patient who has an opening to the stomach and advances physiological ideas about digestion

1839 Schleiden and Schwann (*German biologists*) offer evidence that cells are basic life units

1846 Long and Morton (U.S.A.) use first safe anesthetic, ether

1857 Claude Bernard (France) as a young student physiologist discovers how animal starch (glycogen) works in the liver and the muscles

1858 Charles Darwin and Alfred Wallace (England) advance the idea of organic evolution; in 1859, *Origin of Species* is published

1868 Lister (England) follows Pasteur's ideas about bacteria causing diseases; and introduces antiseptic surgery—later to be replaced by aseptic surgery

1876 Louis Pasteur (France) writes about fermentation and develops finished evidence that germs cause certain diseases

1882 Koch (Germany) identifies the germs causing tuberculosis; works out new methods of bacterial experimentation

1895 William Roentgen (Germany) discovers X-rays

1899 Pierre and Marie Curie (France) discover radium

Auguste and Jean Piccard

Piccard, Auguste (1884-1962) Auguste Piccard was the twin brother of Jean Piccard. He was a Swiss physicist who foresaw SPACE TRAVEL by means of rockets. In 1932 he prepared the way for interplanetary travel by ascending 53,152 feet into the stratosphere in an airtight gondola suspended beneath a BALLOON.

In 1953 he broke another record, this time by descending 10,330 feet under the sea in a steel sphere attached to tanks filled with gasoline. These tanks were pulled down into the water by weights controlled by electromagnetic current. When the current was turned off, the tanks brought the sphere to the surface of the water.

Piccard was born in Basle, Switzerland, in 1884. He was graduated as a mechanical engineer from the University of Basle and the Institute of Technology at Zürich. D. H. J

SEE ALSO: BATHYSPHERE AND BATHYSCAPHE, OCEANOGRAPHY

Piccard, Jacques see Bathysphere and bathyscaphe

Piccard, Jean (1884-1963) Jean Piccard was a Swiss physicist who, in 1934, ascended 57,549 feet into the stratosphere at Dearborn, Michigan. Three years later he tested the possibility of using a number of large balloons to carry an open gondola into the atmosphere. The one hundred balloons he used were six feet in diameter.

Unlike his brother Auguste, Jean came to the United States in 1916 where he taught at the University of Chicago for three years. Returning to his native Switzerland, he taught at the University of Lausanne until 1926 when he returned to the United States to accept a post as instructor at the Massachusetts Institute of Technology. In 1931 he became a citizen of the United States, and five years later he joined the faculty of the University of Minnesota. Jean Piccard was born and educated in Switzerland. D. H. J.

Pickerel see Pike

Pickle see Cucumber

Pickling Pickling (in metallurgy) is the removal, by the use of acids, of the scale, or OXIDE layer, which forms when metals are heated for rolling or forging. Pickling (in food processing) is preservation with BRINE.

SEE: METAL

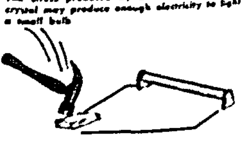
Picric acid see Carbolic acid

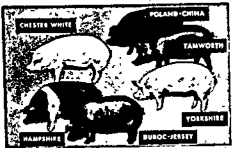
Piezoelectric effect When crystals of certain materials are subjected to a mechanical STRESS, they generate electromotive force. It these crystals are subjected to an alternating electrical stress, they vibrate. The relationship between the mechanical and electrical properties of the CRYSTAL is the piezoelectric effect.

Quartz, rochelle salts, and tourmaline all exhibit the piezoelectric effect. Quartz crystals are used to control the frequency output of transmitters or any other equipment where exact frequency control is required. Rochelle salts are used in microphones; tourmaline may be used in pressure gauges. D. A. B

SEE ALSO: PHOTOELECTRICITY

The stress produced by a hammer hitting a crystal may produce enough electricity to light a small bulb





Some of the types of hogs raised for meat in the United States

Pig The pig family includes both wild and domestic hogs. The word *pig* is usually used to refer to a baby hog. The mother hog is called a *sow* and the father, a *boar*. Hogs are also called *swine*. Farmers raise large quantities of hogs mainly for their tasty meat.

Pigs have a round, heavy body, short legs, and a short tail. Their feet have an even number of hoofed toes. Short bristles grow from their thick skin. Their tough snouts are used for lifting, pushing and digging. Wild pigs are especially strong and fierce. Pigs, or their relative, the PECCARY, are found in almost all temperate areas except Australia. Pigs will eat almost anything.

Hogs were tamed by man as early as the STONE AGE. They may be found on farms in all parts of the world. Man has learned to use almost every part of the hog's body. He eats its flesh (bacon, ham, pork, sausage, spareribs) as well as its stomach, kidneys, liver, ears, brain, skin, snout and jowls. Its fat is rendered (extracting by melting) for lard, skin is tanned for leather, and bristles are used for brushes.

There are many different breeds of hogs. Selective breeding has developed one that produces a maximum of lean meat and a minimum of fat (lard).

Pigs are good breeders. A sow may have two or three litters a year. Each litter may include eight to 25 or more little pigs. A sow may have as many as 28 nipples, more than any other animal. A piglet grows to marketable size, about 200 pounds, in about six months. D. J. A.

SEE ALSO: HOOF, UNGULATA

Pig iron see Iron


Common pigeon, or rock dove

Pigeon At one time, there were supposed to be more pigeons on earth than any other type of bird. Pioneers told stories of how millions of migrating pigeons would darken the sky for hours and the noise of their approach could be heard for miles. The weight of so many pigeons roosting together would break trees and branches throughout the forests. Although pigeons are still very common, their numbers have been greatly reduced. The *passenger* pigeon is extinct, but other varieties are very frequently seen in cities and rural areas throughout the world.

Pigeons are about fifteen to eighteen inches long. DOVES are considered to be a smaller type of pigeon. Pigeon colors range from dull gray or brown to beautiful combinations of white, green, purple, orange, and magenta. Many have irridescent green and violet on their heads and necks.

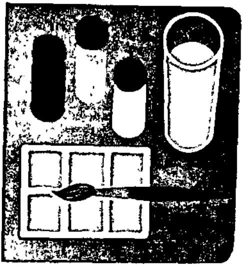
It is believed that pigeons mate for life. Several times a year, a few white eggs are laid in a carelessly-made nest. Young pigeons, or *squabs*, are fed a secretion of regurgitated food from their parent's crop. This is called "pigeon milk." Mature pigeons eat small nuts, seeds, and grain. They can be easily trained to come for food, as is demonstrated by the flocks of pigeons that surround popcorn and peanut machines.

This bird is frequently raised as poultry and has long been used for racing and carrying messages. The *homing* pigeon is best suited for the latter activity. This is a type of pigeon developed through crossbreeding of several varieties to obtain a bird with speed and flight endurance. J. A. D.

SEE ALSO: FOWL

✳ THINGS TO DO

WHAT HAPPENS WHEN TWO OR MORE PIGMENTS ARE MIXED TOGETHER?



1. **Water colors or oil paints may be used for this experiment. The object is to mix two different colors to determine the color of the resulting mixture.**
2. **Mix a small amount of yellow pigment to the same amount of blue pigment. What color is it now?**
3. **Try a combination of red and blue pigments, then red and yellow. Save each mixture.**
4. **Blend a small quantity of two of these together to obtain still another color. Record the results each time and draw conclusions.**
5. **Does there seem to be a pattern to pigment combinations? You will find that, unlike combining colored lights, pigment colors are subtracted by others. The color that is left is the one that is transmitted to your eyes.**

Pigment Pigment is the substance which gives color to paint, to leaves, to skin, and to hair. Mineral pigment is used as a fine powder and can be mixed with liquids to form PAINT (the pigment does not dissolve in the liquid). Shellacs and varnishes show the surface beneath them because they do not contain pigment. Two common paint pigments are *white lead* and *zinc oxide*.

The pigment in the deeper epidermal layers of the SKIN that makes the difference in color in various races is called *melanin*. It is also the pigment of suntan.

Pigments gain their colors only by reflecting parts of the light shining on them. Transparent colors, however, gain their color by allowing the passage of only certain wavelengths of LIGHT. E. M. N.

SEE ALSO: ALBINO, COLOR

Pika see Rabbit

Pike Pike is a blue or greenish-gray fish that lives in lakes and streams. It is called *jack pike* or *northern pike*. A pike usually weighs from two to ten pounds, but fishermen have caught some that weigh over forty-six pounds and are over four feet long. The wall-eyed pike is really a PERCH.

Pike eat other fish, catching them with sudden darts. They eat one-fifth of their weight each day. Pike are often used for food and they are delicious-tasting fish. They resemble pickerel but are larger and have scales only on the sides of their heads.

The pike breeds in spring, with the male and female swimming side by side, dropping and fertilizing over 100,000 eggs among weeds. Each egg is one-third inch long. Eggs hatch by themselves in two or three weeks. In five months the fish have grown to six inches long. In two years they are from fourteen to seventeen inches long. The adult fish have whitish or yellowish spots. P. G. B.

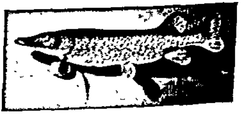
SEE ALSO: PISCES

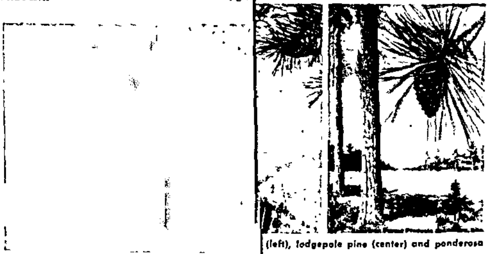
Pile, atomic see *Accelerators*, *Nuclear reactors*, *Nuclear science*

Pilot see *Aviation*

Northern pike

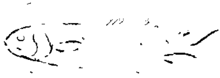
Chicago Natural History Museum





Some pines important for lumber: western white pine (left), lodgepole pine (center) and ponderosa pine (right)

Pilot fish Pilot fish follow ships and sharks in tropical and subtropical seas. These narrow, bluish fish, with dark blue or purple bands across their backs grow to about 12 inches.



Pilot fish

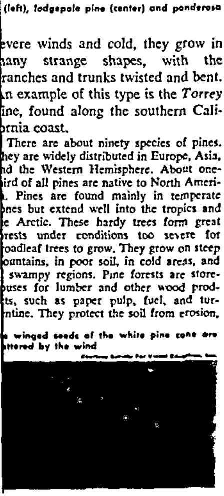
Pine Pines are trees that always stay green. The pine family is easily recognized by its needle-like leaves and woody cones. The seeds are in the pine cones. When pine trees grow in great forests and are shaded, the trunks of the trees are usually clear of branches except at the top where they can get sun. When pine trees are in the open the branches may cover the whole trunk, almost to the ground. Sometimes the branches extend upward and outward and form flat or other shaped tops. Where pine trees are exposed to

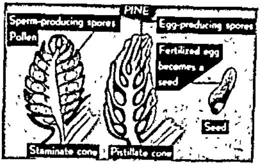
evere winds and cold, they grow in hany strange shapes, with the ranches and trunks twisted and bent. n example of this type is the *Torrey* ine, found along the southern Caliprnia coast.

There are about ninety species of pines. hey are widely distributed in Europe, Asia, nd the Western Hemisphere. About oneird of all pines are native to North Ameri. Pines are found mainly in temperate ones but extend well into the tropics and e Arctic. These hardy trees form great rests under conditions too severe for oadleaf trees to grow. They grow on steep ountains, in poor soil, in cold areas, and swampy regions. Pine forests are storeouses for lumber and other wood prodts, such as paper pulp, fuel, and turntine. They protect the soil from erosion,

e winged seeds of the white pine cone are ttered by the wind

Courtesy Society For Visual Education, Inc.





Courtesy Society For Visual Education, Inc.

Pine trees have male, or pollen-producing (staminate), cones, and female, or seed-producing (pistillate), cones

conserve rainfall and snowfall, and prevent serious flooding. Pine forests provide cover and feed for wild-life, and some species are among the most valuable of all lumber trees. Pines are highly prized by man and are praised in song, literature, and poetry. In addition they serve as the much loved Christmas tree.

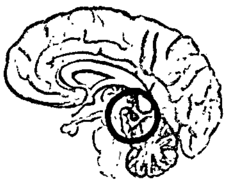
Pines are classified by their wood, as white, or soft, hard or yellow. The wood of *white* pines is generally light in color and weight, and of soft, even texture. It is easily worked and does not splinter. It is used for interior trim and furniture, and where a smooth finish is needed and desirable. The wood of *yellow* pines contains a large amount of RESIN, which shows as yellow streaks when the wood is sawed across the grain. The resin makes the wood heavier and stronger that that of the white pine. It also makes it more difficult to work and to finish smoothly. Yellow pine is excellent for building heavy structures, such as bridges, and for other purposes where strength and durability are required.

The eastern and western white pines are both important lumber trees. These huge trees are used for furniture, doors and sashes, interior trim, patterns, boxes, and other purposes.

The *longleaf* pine of the southeastern United States is a huge tree of great commercial importance. It is the chief source of TURPENTINE and its strong, heavy wood is used for bridges, boxcars, and flooring.

Jackpine is used almost exclusively for paper pulp and is usually second growth timber. The *loblolly* is found in the southern United States and is an important lumber tree. M. R. L.

SEE ALSO: FOREST PRODUCTS, LUMBER



Location of the pineal gland within the brain

Pineal gland The pineal gland is located in the lower central part of the BRAIN. It may be all that remains of a third eye that ancestors of VERTEBRATES (*animals with backbones*) once had. An ancient-type lizard in New Zealand (SPHENODON) has a light-sensitive place on its head above the pineal body. Scientists now know that the pineal is a light-sensitive gland that makes a hormone.

The pineal gland is rich in *serotonin*, a substance secreted by the nervous system. Recently a new hormone, *melatonin*, and an enzyme found only in the pineal were isolated. Research showed that the enzyme acted on serotonin to form melatonin. Melatonin acts on the sex glands to inhibit (stop) the sexual cycle.

Light controls the amount of hormone produced through the sympathetic nervous system. The concentration of melatonin shows a 24-hour rhythm, decreasing during the day and increasing at night. J. C. K.

SEE ALSO: NERVOUS SYSTEM

Pineapple The fruit of the pineapple looks like a giant pine cone. It is native to northern South America. It still grows wild in Brazil. Hawaii leads in the production of this fruit. The fruit may weigh from one to eighteen pounds. Its tough fruit wall is such a protection that it can be shipped to many countries without damage.

Pineapple plant and fruit

The pineapple is a tropical BIENNIAL in the monocotyledon group of flowering plants. The leaves, having very sharp points on the sides, form a rosette around a three-foot stem. The bloom is a bunch of small tightly packed flowers. This is topped by more leaves. The fruit that develops from this flower head is classified as *multiple*, having many ovaries and receptacles fused together. Since the fruit is usually seedless the plant must be propagated by other means. This is done by planting slips, suckers or the top cluster of leaves.

Besides using this plant's fruit, man also makes textile products from piña cloth woven from the white, strong, fibers found in the leaves.

Pineapple also refers to a plant family (*Bromeliaceae*) that includes SPANISH MOSS.
H. J. C.

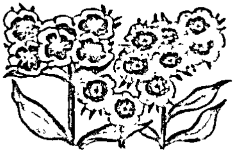
Pinkeye see Conjunctivitis

Pinks Pinks are popular plants in the flower garden. There are many kinds of these charming garden plants. Some of the different kinds are the CARNATION, pink, baby's-breath, bouncing bet, and chickweed. Most pinks are hardy perennials. Members of the pink family have opposite leaves and swollen joints (nodes). The flowers are usually lovely and sometimes fragrant too. Pinks are easily raised in most garden soils.

Pinks properly belong to the genus *Dianthus*, but the name is used for many other plants such as helonias, PHLOX, spigelia, Limonium lobelia, and silene in genus *Lychnis*. Some of the pinks in genus *Dianthus* are the sweet William, which have dense, roundish flower clusters; the maiden pinks, which make turf-like mats and have small flowers; the grass pinks, which are low, fragrant, tufted plants.
M. R. L.

Pinna see Ear

Pinnate venation see Leaves



Sweet Williams, of the pink family

Pinworm Pinworms are parasitic organisms which live in the intestines of humans. They are widely distributed throughout the world in all age groups, but especially in children living in crowded conditions. The female pinworm is about one-fourth inch long and the male is smaller. The body has one pointed end.

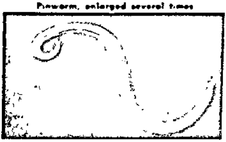
The pregnant female lives in the lower intestine. It is either excreted or crawls out and lays eggs around the anus. Its movements produce intense itching. A coating on the eggs causes them to stick to undergarments, pajamas, skin or bedding. Eggs are transferred to the fingers when the infested area is scratched and on to food or directly into the mouth. The eggs hatch in the upper part of the intestine, the larvae travel down the intestine, attach there and mature.

The most effective prevention is to break the life cycle, by preventing scratching and keeping hands and clothing very clean. Physicians also administer drugs by mouth for five or six days to kill the worm. F. R. B.

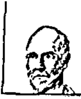
SEE ALSO: NEMATHELMINTHES

Piranha see Tropical fish

Pinworm, enlarged several times



ALFRED B. NOBEL
1833–1896
Invented dynamite, started Nobel Prizes



HIPPOCRATES
460–370? B C
"Father of Medicine"

6824
31462.

MARIE CURIE
1867–1934
Discovered radium and polonium

ENRICO FERMI
1901–1954
Produced first atomic pile and first controlled nuclear chain reaction

THOMAS ALVA EDISON
1847–1931
Invented light bulb, phonograph and mimeograph

NICOLAUS COPERNICUS
1473–1543
First astronomer to say that Earth goes around the sun

LUTHER BURBANK
1849–1926
Invented new varieties of plants

EDWARD JENNER
1749–1823
Discovered smallpox vaccine

CHARLES DARWIN
1809–1882
Conceived the Theory of Evolution through Natural Selection

WILLIAM HARVEY
1578–1657
Discovered the circulation of the blood

GEORGE WASHINGTON CARVER
1864–1943
Experimented with practical botany

SAMUEL F. B. MORSE
1791–1872
Invented telegraph and Morse code

LOUIS PASTEUR
1822–1895
Invented pasteurization

BENJAMIN FRANKLIN
1706–1790
Invented lightning rod

GALILEO GALILEI
1564–1642
Discovered law of pendulum motion

CAROLUS LINNAEUS
1707–1778
Classified the plant and animal kingdoms

SIGMUND FREUD
1856–1939
Started psychoanalysis

GREGOR JOHANN MENDEL
1822–1884
Discovered principles of heredity

BARON ERNEST RUTHERFORD
1871–1937
Contributed to knowledge of radioactivity and atomic structure

GUGLIELMO MARCONI
1874–1937
Invented the wireless telegraph

LOUIS AGASSIZ
1807–1873
Investigated glacial motion and marine life

MICHAEL FARADAY
1791–1867
Discovered electromagnetic induction

SIR ISAAC NEWTON
1642–1727
Discovered laws of light, gravity, motion and color

ALBERT EINSTEIN
1879–1955
Conceived the Theory of Relativity

WILHELM KONRAD ROENTGEN
1845–1923
Discovered X-rays

JOSEPH LISTER
1827–1912
Started antiseptic surgery

ALEXANDER GRAHAM BELL
1847–1922
Invented the telephone